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ROENTGENOLOGIC DIAGNOSIS OF CANCER OF THE CARDIA*

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ROENTGENOLOGIC demonstration of cancer of the cardia is widely assumed to be difficult. Indeed, many clinicians who freely concede the efficiency of roentgen rays in revealing extensive malignant growths in the cardia consider the method almost worthless for excluding early cancer in this region. That opinion seems to be well warranted, for early, small nonobstructive cancers, especially the polypoid new growths, too often escape disclosure. This paper is directed particularly toward a consideration of such cancers.

Roentgenologic examination by modern methods is now expected to disclose all lesions in other parts of the alimentary canal, regardless of their size or location, and failures to discover early cancer of the cardia are disappointing. I am convinced, and my conviction is shared by other roentgenologists, that such failures are caused by depending on employment of the recumbent and Trendelenburg positions to fill the upper segment of the stomach with barium in the expectation of thus exhibiting all organic changes, however small.

This technical detail found its way into the ritual of examination in the early days when complete filling of a viscus was deemed necessary to reveal alterations of the visceral wall by showing them as marginal deformities of the barium shadow. Gradually it was learned that by this method small lesions in most portions of the alimentary canal are often concealed in the enveloping barium, but sole reliance on this procedure for examining the cardia has nevertheless persisted generally, although the same objections apply here as elsewhere.

Probably one reason for this persistence is the influence of the older texts and papers that recommended the method without reserve. Among those whose writings had a deep and lasting effect was Carman who, perhaps more than any other American roentgenologist, helped to make examination of the digestive tract simple, practical and efficient. At the time he wrote, which was a number of years ago, he regarded the Trendelenburg position as especially desirable for examination of the cardia. At that period I was in Rochester observing Carman's work, and I clearly recall certain circumstances that impressed him deeply. A patient, a football coach at a large university, had been referred to Carman by a fellow roentgenologist and intimate friend. Although the symptoms were strongly in-

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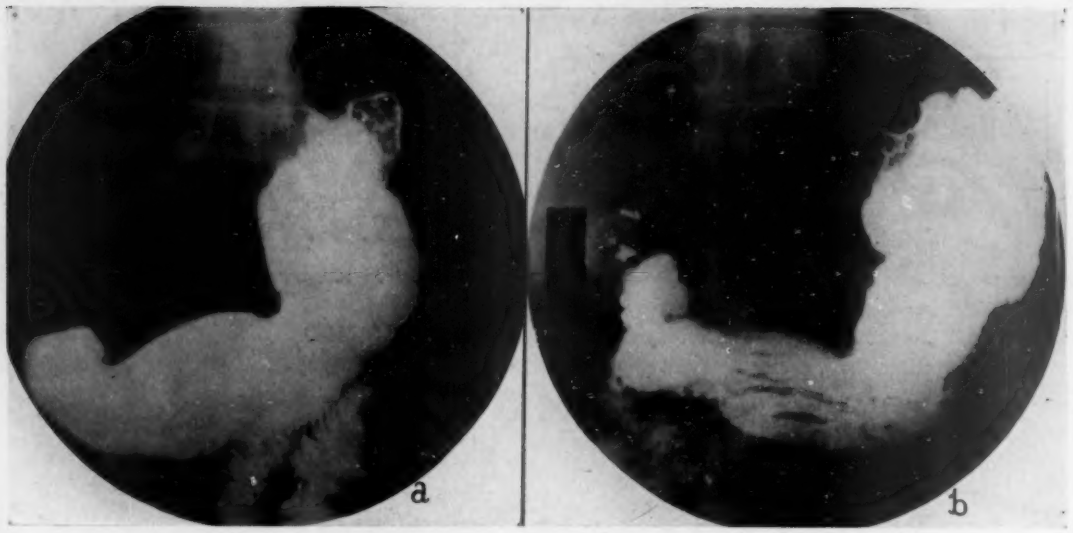

FIG. 1. *a*, moderately extensive, infiltrating cancer of the cardia producing deformity of the gastric wall; depicted in the prone position; *b*, small infiltrating cancer of the cardia near the esophageal opening; depicted in the supine position with cardia well filled.

dicative of a gastric lesion, repeated examinations in the erect posture were negative. Finally, Carman resorted to the Trendelenburg position and a fairly extensive growth, which proved to be an ulcerating carcinoma, was plainly depicted. The technique was appropriate in this instance, and still is in those cases of cancer that invade and deform the wall of the cardiac portion of the stomach (Fig. 1), but its limitations with respect to smaller polypoid cancers were not then realized.

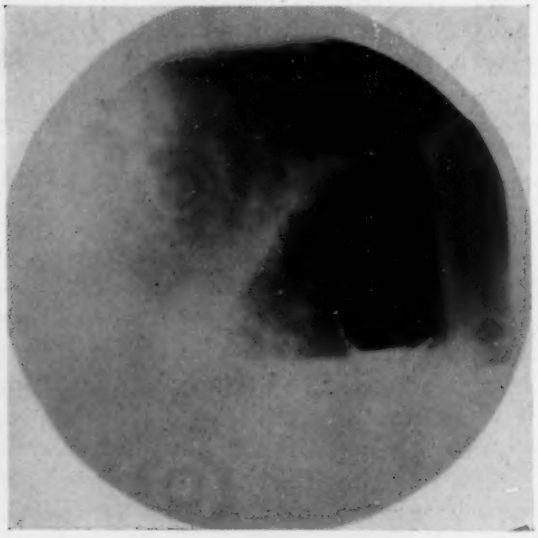

FIG. 2. Shadow of small malignant tumor on mesial aspect of gas bubble, depicted in erect posture.

Had Carman lived, undoubtedly he would have amended his opinion and advice, and as one of his pupils and successors, I feel that such amendment should receive strong emphasis from this clinic in which he worked. He would certainly have discovered that signs of cancer of the cardia should be sought for first in the gas bubble as the patient stands, which is normally transradiant and smoothly symmetrical. The tumefactive growths are then frequently visible as shadows in the air-filled upper segment (Fig. 2), and the infiltrated growths are often manifested by deformity of the dome (Fig. 3). Further, he would have warned that these signs often vanish when the cardia is completely filled with barium (Fig. 4).

Roentgenologists other than myself are well aware of these facts, but apparently they have not been publicized with sufficient force and frequency or have not been duly heeded. In an excellent paper that appeared four years ago, Stewart and Illick* dwelt on the necessity of examining the

* Stewart, W. H., and Illick, H. E. Roentgen diagnosis of carcinoma at the cardia. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *32*, 43–51.

cardia while the first swallows of barium are entering, and described the manifestations of cancer, including deformity of the gas bubble, distortion of the rugae, division of the barium stream issuing from the esophagus, evidences of esophageal involvement and, occasionally, the shadow of a mass in the gas bubble. They added that the supine or Trendelenburg position may be necessary to complete the study, but seemed rightly to regard it as of secondary importance. So thorough is the presentation of Stewart and Illick that little further can be said. However, I wish to lay greater stress on the manifestations that often can be seen in the gas bubble of the empty or partially filled stomach; namely, a shadow of the tumor, deformity of the dome and distortion of the rugae.

From habit and because exceptions are rare, the examiner is inclined to assume that lesions of the alimentary tract cannot be shown without enveloping or coating them with an opaque medium. Thus he is impelled to forget that the gas-filled cardiac end of the stomach normally is so regular in outline and so transradiant that cancers

Fig. 3. Infiltrating cancer producing deformity of mesial wall of dome.

in this region almost invariably must produce visible shadows or deformities of contour. Certainly when the lesion is small, its corresponding shadow or local deformity is not strikingly evident and is likely to be overlooked unless inspection is thorough. In such cases, employment of recumbent positions to fill the cardia often defeats the

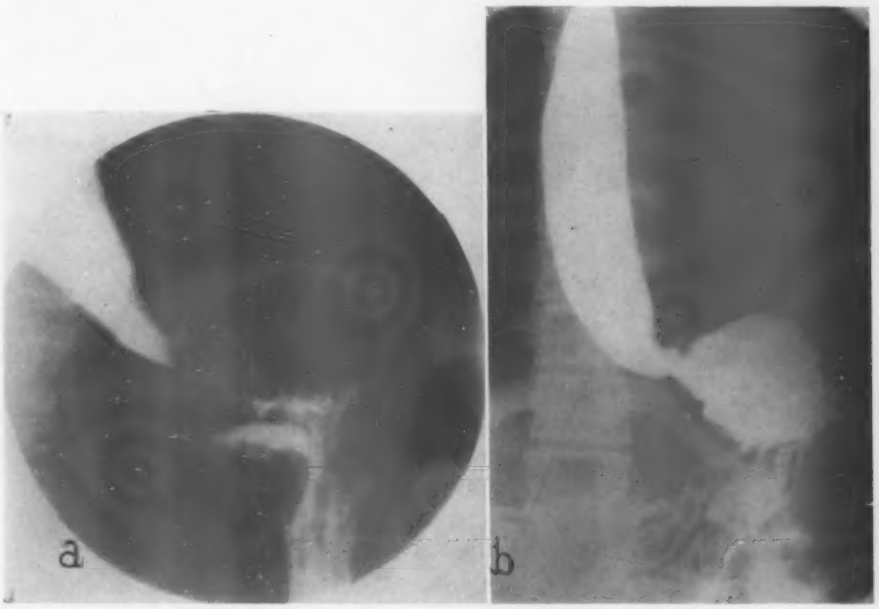

Fig. 4. *a*, polypoid cancer in mesial portion of gas bubble, depicted in erect posture; *b*, same case but with patient in supine position; the tumor is completely obscured.

examiner's purpose, for the slight but significant manifestations are likely to be hidden or effaced by the barium (Figs. 4, 5 and 6). To repeat, I feel that lack of care in inspecting the gas bubble and dependence on filling the cardia with barium are responsible for the majority of failures to disclose cancer in this part of the stomach.

After the gas bubble of the empty stomach has been sharply scrutinized, administration of the suspension of barium may be commenced, but it should be given slowly and each swallow should be watched as it passes through the lower segment of the esophagus. Cancer of the cardia implicating the esophagus will be manifested by distortion or stenosis of the terminal portion, with or without dilatation above an abnormally retarded or continuous outflow of the barium. Often the mixture spreads out over the luminal surface and depicts the internal relief more distinctly. Polypoid growths may stand out more clearly as rounded prominences, and the ground glass appearance produced by scirrhous cancer may be accentuated. Splitting of the stream just after it enters the cardia is an indication of cancer to which Carman directed attention. Obviously, however, to produce this sign the growth must be frankly tumefactive and favorably situated. In my experience this phenomenon has been extremely rare, but more often I have noted more or less deviation of the stream by the tumor. However, I do not regard either splitting or deviation of the stream as important as the shadow or deformity of contour produced by cancer.

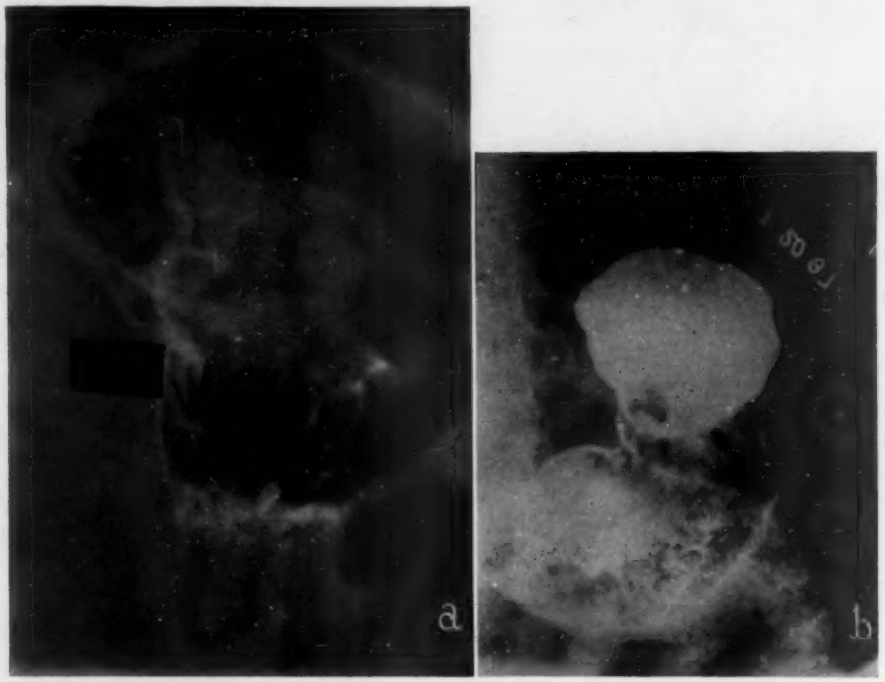

FIG. 5. *a*, large polypoid cancer almost filling gas bubble, as seen in erect position and after administration of one or two swallows of barium; *b*, same case, after administration of more barium and with patient in supine position. The tumor is almost completely obscured.

As the patient continues to drink the mixture of barium and as the stomach becomes partially or largely filled, the gas bubble distends the dome and can be studied to greater advantage than before. The opportunity to discover or exclude adventitious shadows or deformities should not be neglected. Special attention should be given to the mesial aspect of the dome, for this seems to be a favorite site of cancer.

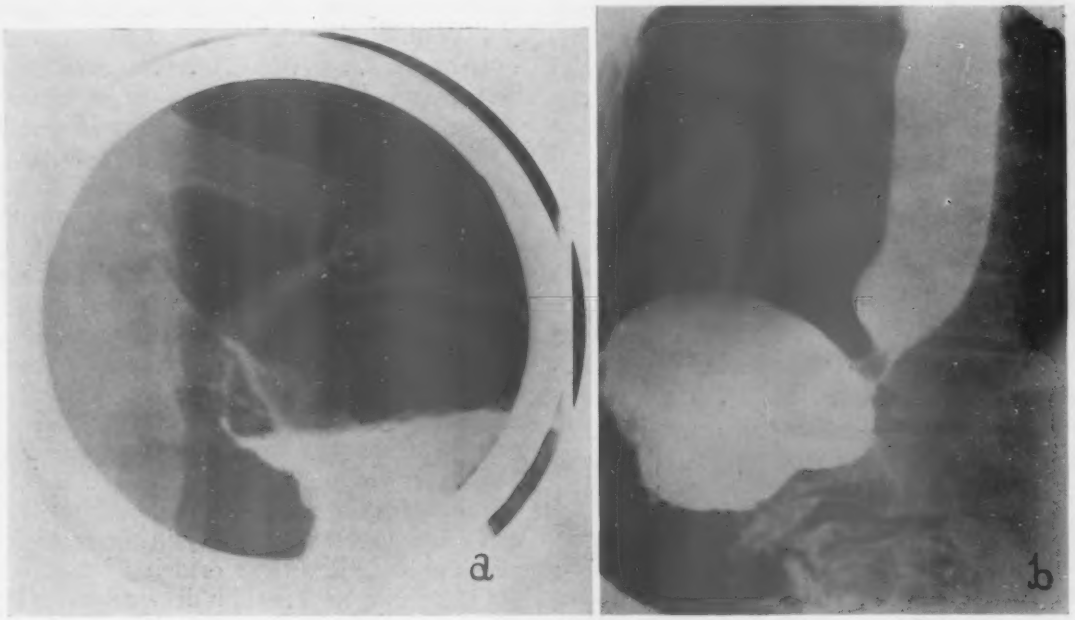

Fig. 6. *a*, small tumefactive cancer on mesial aspect of dome, depicted in erect posture; *b*, same case, with patient in Trendelenburg position. The tumor is invisible.

At this stage also the barium can be forced up into the cardia by pressure over the dependent portion of the stomach in order to coat the mucosa and facilitate further study of the internal relief.

As a final step examination in the recumbent or Trendelenburg position can be carried out if it seems desirable, but I seldom resort to it. With this technique, evidence of extensive cancer is likely to persist, and sometimes this corroboration is worth while. However, it seems to me that the chief value of the procedure is in differential diagnosis, for example in disguishing cancer from diaphragmatic hernia.

In differential diagnosis, the first consideration is to ascertain whether or not a shadow in the cardia represents a lesion. Occasionally a shadow in this area is caused by the apex of the heart (Fig. 7), or by a portion of the spleen or by enlarged glands but, in any such case, the shadow has a sharp regular margin and overlying rugae are normal. Further, a shadow caused by the spleen usually occupies a characteristic situation on the side of the greater curvature and a shadow produced by the heart is pulsatile and disappears on deep inspiration. Glandular metastasis is more difficult to exclude. When it is certain that a tumor is present, its malignant character may reasonably be assumed. Benign growths may occur in the cardia, but they are very rare and it is notorious that ap-

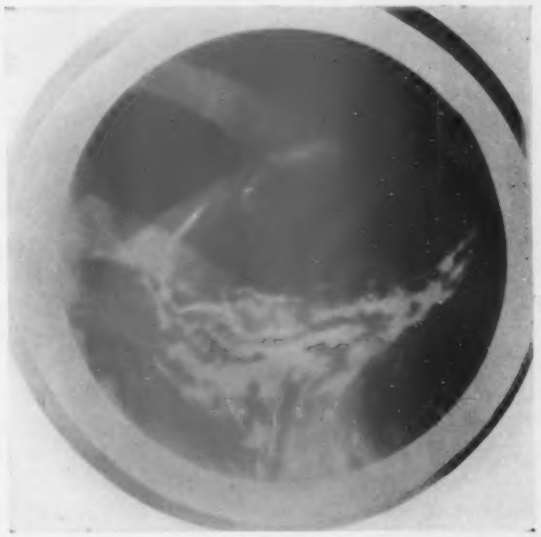

Fig. 7. Shadow of apex of heart in gas bubble. The shadow pulsated and was not visible in the gas bubble on deep inspiration.

parently benign gastric tumors often prove to have a low degree of malignancy.

When the most striking manifestations are those produced by invasion of the esophagus, distinction from benign stricture, cardiospasm, low diverticulum, and so forth, is necessary but seldom difficult, for the signs of all such affections are usually characteristic. Further, when cancer of the cardia extends into the esophagus the gastric portion of the growth produces either a shadow in the gas bubble or deformity of the gastric wall. On this basis extension from the cardia may be distinguishable from cancer restricted to the esophagus. Deformity of the dome is, of course, not pathognomonic of cancer, for diaphragmatic hernia is a common cause. Hernia of the stomach, if not otherwise obvious, is usually demonstrable by angulation or deformity of the lower end of the esophagus but, occasionally, recumbent positions are necessary. Demonstration or exclusion of hernia with implication of the large or small bowel may require observation of the course of the opaque meal or examination with the enema.

It is my earnest belief that with the technique outlined the presence of cancer of the cardia, whether advanced or early, can be established as readily and reliably as in other portions of the alimentary canal.

DISCUSSION

DR. GEORGE W. GRIER, Pittsburgh, Pa. Dr. Kirklin, with characteristic carefulness and thoroughness, has presented to us a problem that has been a very trying one for many years. I can remember as long ago as 1913, I think, seeing a patient in whom cancer of the cardiac end of the stomach was suspected and in whom we were not able to demonstrate it, but who went to Baltimore and they were not able to demonstrate any such lesion there. Sometime later, we examined the patient a second time and were able to demonstrate this cancer of the cardiac end of the stomach which undoubtedly by that time had grown to such a size that it could be demonstrated by the methods and with the knowledge we had at that time.

In all the years since, this subject of carcinoma of the cardia, to me at least, has been a rather embarrassing and perplexing one, and I am very much indebted to Dr. Kirklin for demonstrating the fact that carefulness of technique will discover these lesions which otherwise might be overlooked. As a matter of fact, that statement applies to the diagnosis of any lesion in the stomach.

Dr. Kirklin very rightly, I think, said that only large lesions can be demonstrated by the usual method of examination; that is, by placing the patient on the back with his stomach filled with the barium meal. I think a possible exception to that, and I believe he refers to this in his paper, is a case in which the lower end of the esophagus is also involved. Those cases are usually not so difficult to demonstrate because as you watch the patient swallow, you can usually demonstrate the dilated esophagus and often also the deformity in the esophagus which extends into the stomach

I am willing to accept his demonstration here of the actual tumor. If anybody had asked us ten years ago if we could demonstrate cancer of the stomach without any preparation, I am sure we would all have said that we could not. But I have seen within the last year a number of cases in which we thought we could actually see the tumor in cases of cancer of the stomach as it protruded into the gas bubble. The partly filled stomach, and undoubtedly the technique with the thick, mucilaginous barium meal should demonstrate these lesions with greater frequency. Dr. Kirklin, I believe, also referred to that when he spoke of the deformity of the gastric rugae as demonstrated with that sort of a meal.

He spoke of the technique of demonstrating mucosal relief as being not easy. It requires experience accurately to demonstrate lesions with barium and this is particularly true if you try to demonstrate lesions with the patient lying on his back. You have to work that gelatinous material around in order to have sufficient of the stomach wall covered to demonstrate the mucosa, but I believe we will become more adept in the use of that method and probably it will prove itself to be of valuable aid in the demonstration of cases of cancer of the cardiac end of the stomach.

In 1933, in this room, before this Society, I read a paper which seemed rather silly, I suppose. The whole object of the paper was to call the attention of everyone to the fact that there was really great advantage in making exposures of the stomach with the patient under the

fluoroscope. That is a trivial thing to write a paper about, but certainly if that technique is always followed, I am sure we would be able to demonstrate more of these cases of cancer of the cardiac end of the stomach. Dr. Kirklin, while he did not refer to it in that way particularly, demonstrated several times that lesions were shown with the patient in one position and not in another. It is obvious that if these cases were sent out and examined in another room by a technician probably these lesions would not be demonstrated. It is probably unnecessary even to call attention to that fact at this date because during the seven years that have intervened, the development of apparatus has popularized the method of making exposures on the fluoroscopic apparatus, more particularly the spot film, and I am sure that almost everyone in this room follows that method.

What impressed me most in Dr. Kirklin's paper is the fact that we must be extremely careful in the examination of the stomach.

Dr. George E. Pfahler, Philadelphia. These discussions by Dr. Kirklin and Dr. Grier emphasize what I have observed during many years. I am convinced that the older a man is and the more experience he has had in roentgenology, the more detail and the more work he is apt to do on a stomach case. The reason for this is the fact that we older men have had more time and opportunity to make mistakes and we have made them. Therefore, we try to avoid such mistakes in the future by going into great detail and doing a lot of work to check on all observations.

I know that in Philadelphia many of my colleagues think that I am foolish in doing the tremendous amount of work that I do on any particular stomach case. The reason for this is just what I have mentioned and which has also been brought out by Kirklin, namely, if we do not go into all these details, we are going to overlook some cases and then we will have the embarrassment that is particularly damaging to an older roentgenologist.

I would like to emphasize one thing particularly that was brought out by Dr. Kirklin. He said, "We give this meal very slowly." That little statement seems very simple. You probably will say that you all do that. Maybe you do. Let us consider what happens when that meal is given very slowly. Each time the patient swallows, and the smaller the swallow of liquid is, the more air is carried down into the stomach by that procedure. He thus enlarges the bubble and that will enable the roentgenologist to see a lesion at the cardia which otherwise would be overlooked.

Another method of developing a bubble at the cardiac end of the stomach can be utilized for these studies by the administration of a Seidlitz powder, instructing the patient not to belch, and then you will observe gradually a fine large bubble filling the cardiac end of the stomach. That will enable you to pick out the cardiac lesion more easily.

Dr. Ross Golden, New York City. I was very much interested in Dr. Kirklin's demonstration to see what large lesions could be obscured in the fundus of the stomach by the barium. It seems to me, as Dr. Grier has emphasized, that the difficulty can be obviated by giving only a small quantity of barium meal.

With a tilting table spot film device which I have been using for the last two or three years, I find that I have been able to do a complete examination of the esophagus and stomach and duodenum in most cases, using from 1 to not more than 4 fluid ounces of barium suspension. Only two or three swallows at the most are needed for the examination in the upright position. Then when the patient is immediately put in the horizontal position, supine, lesions like those under discussion in the fundus will not be obscured; the barium will outline the muscosal folds and any masses that may be present, particularly if one rolls the patient back and forth from right to left in both supine and prone positions. With the spot film device, one can make as many as four small exposures of the fundus on one film, provided the fundus is small enough, by diaphragming down in any position in which it seems advisable to have a record for further study.

Two very helpful points, in my experience, are first, the use of a small quantity of barium suspension and second, having the patient take at least one swallow while lying in the prone or supine position.

Dr. Solomon Fineman, New York City. I am indebted to Dr. Kirklin for the privilege of listening to his very excellent and detailed presentation of the subject.

I should like to stress one point, which I am sure is well known to him, but which he did not refer to in his paper, namely the routine use of the left lateral position when examining for cancer of the cardia. Masses in the cardiac end of the stomach located on the anterior or

posterior wall are at times not visualized in the supine or prone positions, because they may be completely obscured in these positions by the overlying barium content of the stomach. By placing the patient in the left lateral position these masses and the filling defects they produce may be brought into relief.

I recently have examined two patients in whom I could not visualize cardiac tumors in the usual supine, prone and oblique positions, but in whom filling defects at the cardia were clearly visualized in the left lateral position.

DR. PFAHLER: Recumbent or vertical position?

DR. FINEMAN: In the recumbent position. I have made it a rule to study every case routinely in the left lateral recumbent position, rotating the patient slightly from side to side. I have found that very slight rotation will at times bring into view a filling defect of the anterior or posterior wall which is not visualized in any other position.

DR. GEORGE W. HOLMES, Boston. I think such papers as the one Dr. Kirklin has presented, emphasizing technique, are very much needed on our programs. I would be glad to see more of them. Roentgenologists in recent years have had a tendency to get away from problems of technique. In the old days, we used to have many arguments over technique. I would like to see this practice revived.

Dr. Golden spoke of a procedure that I would like to emphasize, and that is, we do not often enough, I think, have the patient take the first swallow in the prone or supine position. A number of things can be found out by this method that will be missed if the first swallow is given only in the upright position.

I would also like to call attention to a sign which we have found of some value. The space between the gas bubble and the diaphragm is easily outlined without barium, and a thickening of this space usually means something abnormal; it does not always mean disease.

DR. ALEXANDER H. PIRIE, Montreal, Canada. One has not only to diagnose carcinoma of the cardiac end of the stomach, but occasionally we have to negative the diagnosis. I would like to ask Dr. Kirklin if he has ever had to negative a diagnosis of carcinoma in the cardiac end of the stomach, especially in cases of this sort. A man has had a gastroenterostomy for thirty years. The cardiac end of the stomach is atrophied and there is a large space between the cardiac end of the stomach and the diaphragm. You have to get that filled up somehow. How are you going to do it and how would you negative a diagnosis of carcinoma of the cardiac end of the stomach? (It can be done by distending the stomach with air.)

Dr. KIRKLIN (closing). Frequently, as one scans the upper portion of the abdomen very rapidly, the mass can be seen protruding into the gas bubble. It is also true, as Dr. Pfahler mentioned, that as the patient's stomach fills, the gas bubble enlarges, for two reasons, I think. One is that the barium suspension forces the gas into the upper portion of the stomach, and the patient also swallows a certain amount of air during ingestion of the meal.

There has been some discussion concerning the amount of barium given and the technique of demonstrating the barium-coated surface of the lesion. I have found it very helpful to make pressure over the stomach, force the barium suspension up into the cardia and then relax pressure. There is usually enough barium remaining on the wall of the stomach so that one can get a satisfactory view of the entire internal relief of the cardiac portion of the stomach.

I think I have answered the questions asked, except for that of my friend, Pirie. The stomach, after operation, offers the most difficult problems that we have to deal with. We do much as he does, that is we try to obtain a complete view of the mucosal pattern, both with the fluoroscope and the spot film. I don't think it makes much difference which is used.

Vol. 41, No. 6

VASCULAR TUMORS AND ANOMALIES OF THE SKULL AND BRAIN

FROM A ROENTGENOLOGIC VIEWPOINT*

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TO BE able to state a problem in definite terms is to take the first long step toward its solution. Therefore, let us first try to understand just what these lesions are before attempting to discuss them.

The term angioma means a neoplasm of connective tissue origin which is composed of vessels. If it is of blood vessel origin then it is called a hemangioma, or if formed of lymphatics it is termed a lymphangioma. The lesions we find in the head are hemangiomas, and until quite recently they were thought to be definitely neoplastic, chiefly because of the opinions expressed by Virchow in 1863 and reiterated and concurred in by Ribbert in 1898. Later in 1908 Enders concluded from his studies that these lesions were malformations with neoplastic tendencies, and in 1913 Borst published his views which indicated that they were purely anomalies. In more recent years Cushing and Bailey, Dandy, Wolf and Brock and others have concluded that the lesions are congenital malformations which under certain stimulants are capable of growing. It seems then that if this be true we are justified in concluding that the malformation must include in its makeup an anlage which is potentially neoplastic.

When we consider the complex manner in which the cranial and intracranial vascular system develops, the wonder is that more anomalies do not occur. Bailey points out that the embryonic vascular system is formed in three layers by the development of the skull and meninges, and that as the brain develops the blood vessels must follow its complicated evolution so that occasionally the three layer system is disrupted, which results in the formation of anomalies. It can thus be seen that these malformations may well retain some of their embryonic characteristics which later, under some irritant, would result in the bizarre formations so frequently seen.

Cushing and Bailey do not like to call these malformations tumors, chiefly because they are able to demonstrate glial tissue between the vessel convolutions. But if we accept Ewing's definition of a tumor as an autonomous new growth of tissue, it would be hard to escape classifying the blood vessel walls of these lesions as tumorous material. Such a discussion might be carried on ad infinitum, but suffice it for the purposes of this article to call the lesions vascular malformations.

Such malformations are not common, or at least we do not often find them. It is quite possible that many exist and are never discovered because of being asymptomatic. Those that we do find constitute slightly less than 2 per cent of all intracranial new growths, and it is interesting to note that it is rare to find such an anomaly below the tentorium. Their sites of election seem to be the parietal region, often near the angular and supramarginal gyri, and in the frontal portion of the cerebrum. They often involve the middle and anterior cerebral vessels and their terminal branches and only rarely the cerebellar vessels.

Virchow classified the hemangiomas into two main groups, the cavernous and the racemose. His chief point of differentiation was that the cavernous type possessed vessels which were usually large and their walls often enclosed more than one lumen, while the racemose variety was composed chiefly of thin-walled telangiectases with or without true veins and arteries. Cushing and Bailey classify these malformations in-

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FIG. 1. Venous angioma situated in the posterior parietal region. Note the convoluted appearance of the calcification, and the absence of large vessel channels leading to the lesion.

to the telangiectases, the venous angiomas and arterial or arteriovenous angiomas. The arteriovenous type is often designated as aneurysmal because the blood will occasionally be found flowing directly from the arteries to the veins. It is in the presence of this type of lesion that we are able to hear a bruit with a stethoscope. It seems highly probable that this almost pathognomonic sign is not infrequently missed because one does not think to use a stethoscope on the head. The term cavernoma is occasionally applied to a large angioma of the cavernous type.

The telangiectatic variety of vascular anomaly is rarely recognized in the roentgenogram. The lesions are small, probably congenital, and would not be expected to give rise to any clinical manifestations because there is no tumefaction. It is not uncommon to find these small anomalies almost anywhere in the brain and over the cortex. Some have been described as occurring in connection with the fourth ventricle and in the pons. It seems highly probable that small telangiectases may possess a dormant tendency to grow and develop into the larger forms of vascular anomalies when subjected to some stimulus. They may on rare occasions contain small flecks of calcium but, as a rule, the lime deposit would not be found in any characteristic form so that an accurate diagnosis would be extremely difficult to make. If small flecks or punctate deposits of calcium can be recognized as occurring over the cortex, in the meninges or within the brain substance, and if the clinical findings are practically negative we might be justified in suspecting the presence of telangiectases. It is perhaps unnecessary to mention that without a history and good stereoscopic films one would be at a distinct disadvantage in trying to make a differential diagnosis. Deposits of "brain sand" might be caused by slight hemorrhage or change in one or more of these anomalies, but "brain sand" will be discussed more at length in a subsequent article. Our chief concern

FIG. 2. Posteroanterior view of Figure 1.

should be to differentiate the occasional small, practically amorphous deposit of lime salt found in a telangiectasis from a glioma, and this is usually possible if we bear in mind the characteristics of the gliomas which have been discussed in a previously published article.

The venous angiomas (angioma venosum) have been classified into three groups by Cushing and Bailey who designate them as simple varices, serpentine varices, and the racemose or cirsoid varieties. These are purely descriptive terms and do not indicate any fundamental differences between the types. Very little is known about the early history of such anomalies, but evidently they tend to originate on or near the cortex and grow inward in a conical formation with the apex most deeply situated. It seems highly probable that one of these lesions may be present for many years without its presence being suspected, until for some reason it may begin to enlarge or change its characteristics. The patient will then complain of headaches with or without epileptic seizures which are usually Jacksonian in type. The angioma venosum is almost always found in the cerebrum posterior to the fissure of Rolando; exceptions to this location are not common.

Fig. 3. Another example of a venous angioma. Note that the calcification is arranged in parallel lines.

Fig. 4. Posteroanterior view of Figure 3.

The percentage of the venous anomalies which become calcified is difficult to state with accuracy because many undoubtedly go undetected. But of those we encounter, about 80 per cent contain sufficient lime salts to cast a recognizable shadow on the roentgen film. These shadows are apt to be rather characteristic or at least suggestive of the type of lesion they are in. If the calcification is in linear streaks of a more or less convoluted form, and particularly if the streaks show a tendency to an arrangement suggesting parallel lines, we can be fairly certain that the lime is deposited in vessel walls. If the calcified vessels are seen end on, the shadows will appear as more or less true circles. Occasionally the linear shadows may be indistinct so that we might be led to think of the possible existence of a slow-growing type of glioma. The history would usually aid us in differentiating, and in addition there would be, in all probability, some other skull changes in the presence of a glioma, such as atrophy of the various parts of the sella turcica. The angioma venosum rarely gives rise to an eleva-

Fig. 5. A venous angioma close to the atrium of the right lateral ventricle. Note the circular shadows indicating calcified vessel walls seen end on.

tion of intracranial pressure, nor is it accompanied by any increase in the size of the vascular channels seen on the inner table of the calvarium. These facts frequently make it possible to differentiate the venous angioma from the arterial type which we are next to discuss. It might be well to mention in passing that the intracranial angiomas, particularly those involving the meninges, are not infrequently accompanied by nevi of the face or scalp, and the patient is apt to suffer from epilepsy of the Jacksonian type.

The arterial angioma, or angioma arteriale, as Cushing and Bailey term it, like the venous variety is an anomaly which usually seems to originate in the meninges, and burrows in a conical form into the brain. These lesions occasionally reach the ventricles into which a hemorrhage may occur, thus causing the death of the patient. It is not difficult to see why most vascular anomalies are found originating in the meninges if we remember that the final branching of the cerebral arteries begins in the pia mater, and that the anomalies usually involve the smaller terminal vascular branches. As mentioned before, it is this type of angioma that often becomes aneurysmal and so gives rise to a bruit which may be noted and complained of by the patient. The arterial angioma is apt to be larger and far more complicated than the venous variety. Occasionally such a lesion, when it occurs in the frontal region, will involve an orbit and produce a unilateral exophthalmos which will be pulsating. This pulsating characteristic would be important to note when differentiating from a meningioma which may produce a non-pulsating unilateral exophthalmos. A detectable bruit was previously mentioned as an almost pathognomonic indication of the presence of an angioma arteriale, but we cannot exclude from our consideration the possible formation of a bruit within an angiomatous meningioma, or an occasional arteriovenous fistula. In the presence of a well-developed arterial angioma, which incidentally is not exclusively arterial but also contains veins, the carotid arteries may be considerably enlarged and there may be

Fig. 6. Arteriovenous angioma of the posterior parietal region. Note the streaks of calcification and large vessel channels.

some cardiac hypertrophy as well. This was pointed out by Holman in 1924, and later by Wolf and Brock.

Like the venous variety, the arterial angioma frequently contains deposits of lime salts in the vascular walls, so that in the roentgenogram we often see the same type shadows already described. As a rule, however, the calcification is more extensive in the venous angioma. It might be well to mention the fact that occasionally either type of anomaly may displace the pineal gland away from the site of the lesion. The angioma arteriale is usually accompanied by one or more enlarged arterial channels in the inner table of the calvarium, and not infrequently there will be evidence of atrophy of portions of the sella turcica. Without calcification the presence of enlarged vessel channels might be thought of as an indication of the presence of a meningioma which is a far more common tumor, but if after a careful study of the films no evidence of bone reaction is seen, the chances are not great of its being such a lesion. Occasionally the calcification in an angioma will not be confined to the vessel walls but will be deposited in the immediately adjacent tissues in a filmy or more or less dense amorphous mass, and unless we could detect the telltale linear streaks of vascular wall calcification, it might be very difficult to differentiate from a meningioma. As a rule, however, the angiomas being essentially congenital malformations are more apt to be found in younger patients than are the meningiomas, although, as was pointed out in a previous article, meningiomas have been found in children. It might not be amiss to mention here that the cases used as a basis for this article varied in age from ten months to fifty-four years, the average being thirty-one years.

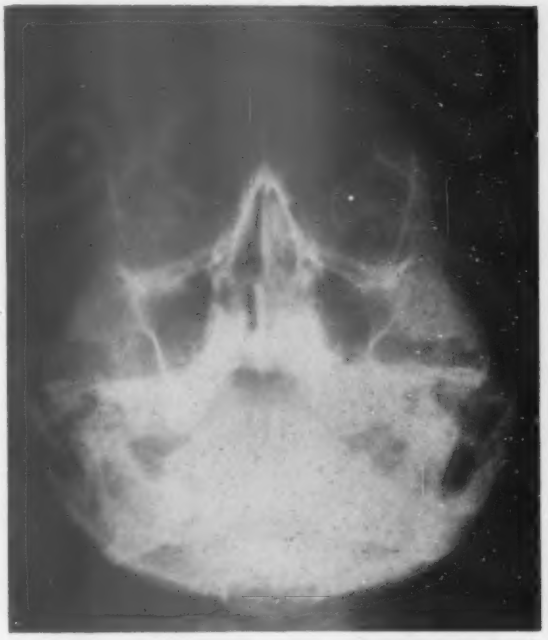

Fig. 8. Hemangioblastoma (Lindau's disease). Note the ring-like shadows in each orbit caused by calcification in the choroid, lens and orbital angiomata.

Fig. 7. Arteriovenous angioma of the frontal region involving the frontal sinus. Note the large vessel channels and the fine streaks of calcification directly above them.

The roentgenogram is usually the deciding factor in making a diagnosis of a vascular anomaly, and rarely will it be necessary to resort to encephalography. The encephalogram will permit only of locating the lesion, and unless some subarachnoid gas might find its way around a few of the vessel convolutions we could not state un-

FIG. 9. A typical example of a hemangioma of bone situated in the superior frontal region. Note the lack of enlarged vessel channels leading to it, and that there is no evidence of elevated intracranial pressure.

equivocably what the lesion was. But with the history and location of the lesion accurately determined, a diagnosis is not infrequently possible. The importance of making an accurate diagnosis of the presence of one or more of these vascular anomalies cannot be overestimated, because as a rule surgical interference is most hazardous. Radiotherapy should be tried on two scores; first, to attempt to stop the enlargement of the lesion, and second, to try to induce an endarteritis which would reduce the size of the lesion and its blood supply, and so at least make possible an operation which otherwise would be impossible. To do this, most intensive irradiation is necessary, with cross-firing, so that the lesion may receive at least 3,000 or 4,000 r, and unless the case becomes suddenly a surgical emergency, the dose may well be repeated in about four to six weeks. Personally, I am in favor of administering the total dose fractionally, supplying 200 or 300 r daily or every other day until the total has been reached. The actual method of treatment and total dosage cannot be stated dogmatically because as yet too few of these lesions have been treated and subsequently inspected to permit of any definite conclusions being drawn.

The hemangioblastomas truly conform to Ewing's definition of a tumor as being an autonomous new growth. Sabin has clearly shown that such tumors originate from angioblastic cells, and in 1926 Lindau published his important contribution to the knowledge relative to the hemangioblastomas. He showed that the cerebellar lesions are frequently associated with hemangiomata of the retina (von Hippel's disease) and with lesions in the liver, kidney, pancreas, spinal cord, and also with hypernephromata and tumors of the epididymis. The cranial hemangioblastomas are almost invariably subtentorial in origin and are not infrequently associated with the choroid plexus of the fourth ventricle. The tumors are rather prone to become cystic and, as Cushing and Bailey point out, the cyst will contain a small mural tumor nodule which must be removed if an operation is to prove successful. These authors also show that the hemangioblastoma may begin as a comparatively simple capillary formation and progress to the cavernous and cellular

FIG. 10. Another example of hemangioma of bone.

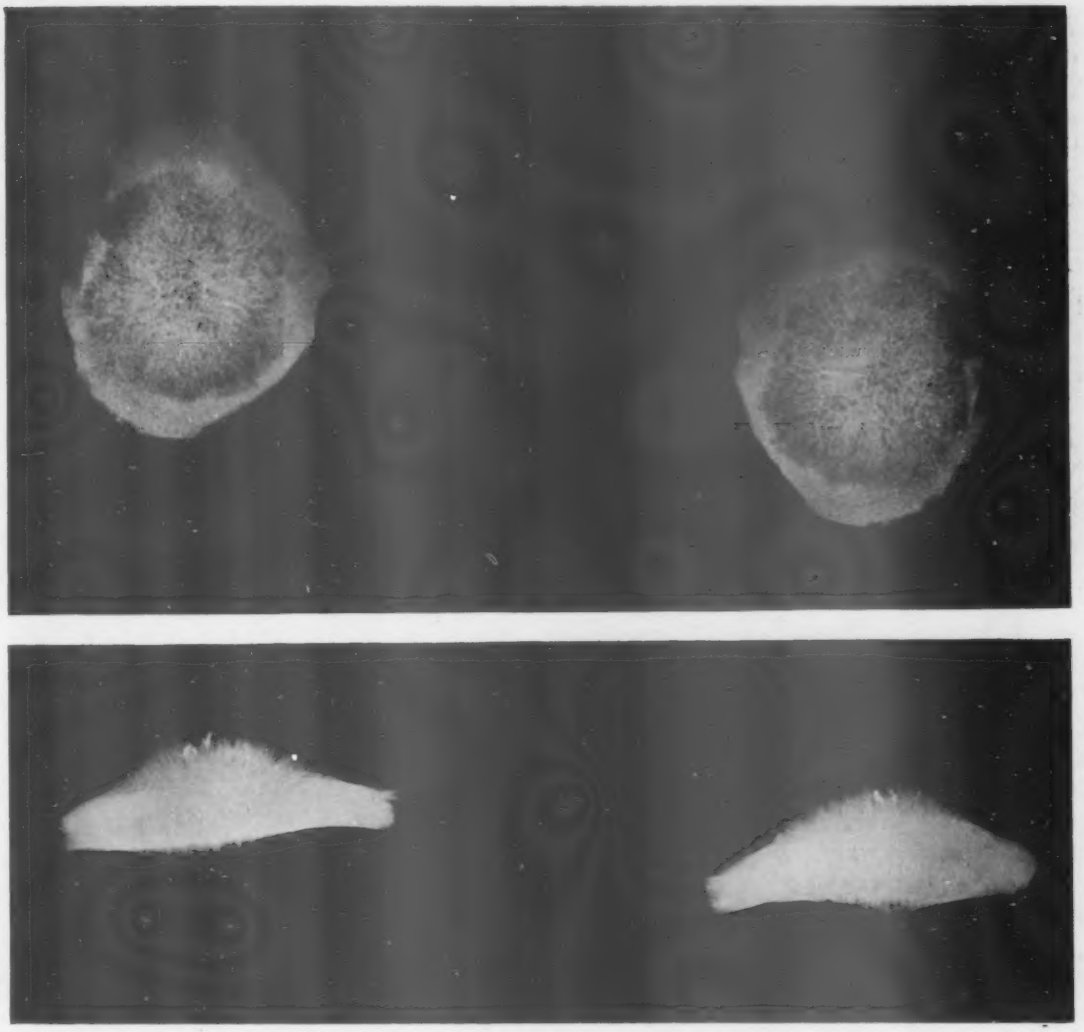

FIG. 11. Two views of a hemangioma of bone removed from the skull.

forms. Hemangioblastomas, like the vascular anomalies, are essentially congenital in origin and therefore the anlage is probably present at birth. Due to the rarity of tumors of this type, statistics are difficult to evaluate, but the age of election for the occurrence of such a lesion is evidently during the third decade, although children are by no means immune.

There is very little to say about the roentgen diagnosis of the hemangioblastomata. If the tumor involves the fourth ventricle we might expect to find evidences of hydrocephalus, but if the tumor was situated in one of the cerebellar hemispheres even this evidence would be lacking. It is very unusual to find enough calcium in such a tumor to cast a shadow on the film, in spite of the fact that it grows very slowly, and symptoms may be evident for about a year before becoming sufficiently marked to bring the patient to the neurosurgeon. The not infrequent accompaniment of retinal angiomatosis with hemangioblastomata may permit of making a preoperative diagnosis, and as occasionally such lesions in the retina give rise to intraorbital calcifications, the roentgen examination may play an important rôle in the final diagnosis. It is also of interest to note that this condition may give rise to detached retinae.

When a hemangioblastoma occurs in a

FIG. 12. A cavernous hemangioma of bone directly overlying the left middle meningeal channel. This has produced no bony spiculation.

child, we may be unable to make a differential diagnosis, first because such tumors are extremely uncommon, and second because a posterior fossa lesion would be much more apt to be a cystic astrocytoma, and third in either case the history would be similar and the roentgen findings would merely consist of evidences of increased intracranial pressure. In an adult, however, the likelihood of a cerebellar lesion being an astrocytoma is considerably lessened, but other rare lesions must be considered as possibilities such as cysts of teratoid origin. Teratoid cysts are prone to calcify and so they usually would not prove a confusing factor. The finding of calcification in the orbits, as seen in Figure 8, particularly if associated with any cerebellar symptomatology, would be strong presumptive evidence of the presence of a hemangioblastoma.

Nothing of an authoritative nature can be said regarding the radiation therapy of the hemangioblastomas because too few have been available for treatment. As has been pointed out, a preoperative differential diagnosis is not common, and when such a lesion is found at operation, if it is favorably situated to permit of a complete removal, a recurrence is not likely. However, if such a lesion be found and whether or not the surgeon is able to remove it completely, intensive irradiation should be instituted because we are dealing here with a true tumor. In spite of meager experience with such lesions, the same type of treatment might well be applied as suggested for the angiomatous malformations, in the hope of forestalling any further growth of possible tumor remains.

The hemangiomas of bone are rare; they constitute only about 1.2 per cent of all bone tumors, but one of their favorite sites of election is the skull where they usually are found in the calvarium, involving either the parietal or frontal bones. The tumor is benign and like angiomas elsewhere its cause is unknown, although cases have been reported which seemed to bear some relation to trauma and so make it appear at least possible that trauma might be a contributing factor in the stimulation of a dormant anlage. The lesion usually begins in the diploe and expands the inner and outer tables in a somewhat fusiform manner, but rarely attains any great size so that is is not uncommon to find such a tumor present without any symptoms whatever.

The hemangiomata of the skull bones occur in two forms, as the more common cavernous variety or in a comparatively rare capillary form. They usually begin in the diploe and may produce either bone hypertrophy due to apparent invasion of the bone, or there may be a purely osteolytic reaction. In either case, the lesion is localized and may or may not be surrounded by bone of increased density in the form of a thin ring of osseous tissue. The tumor does not have a tendency to destroy the overlying periosteum which is almost always raised but intact. When spiculation occurs the spicules seem to radiate from a central point and do not appear perpendicular to the skull tables as is the tendency of spicules produced by a meningioma or sar-

coma. This interesting tendency was noted by Bucy and Capp in 1930.

In the presence of a hemangioma of the calvarium there will be no vessel channel leading to the lesion, or if one is seen crossing the involved area it will not be enlarged and should be approximately comparable to corresponding channels of the opposite side. In the presence of a meningioma we would expect the vessel channels in the immediate vicinity to be enlarged and increased in number. Another condition which might be confused with a hemangioma of bone is a localized area of osteitis fibrosa with giant cell tumefaction. This condition is also without increase in surrounding vascularity and is a fusiform swelling, but there is not likely to be any spiculation and the bone structure takes on a most heterogeneous formation, quite unlike the more or less orderly form of the hemangioma.

The type of calvarial hemangioma which does not produce bony spiculation may at times go unrecognized because its appearance may so simulate a pacchionian impression as to be indistinguishable. If there is any evidence of bony swelling seen in profile films the area of radiolucency is not due to a pacchionian impression, and if a careful study of the steresocopic films shows any tendency toward trabeculation within the area, giving a somewhat multilocular appearance, the chances are we are dealing with a hemangioma. Occasionally, we might find a small epidermoid cyst or a leptomeningeal cyst producing a radiolucent area in the calvarium simulating a hemangioma. The epidermoid, like the hemangioma, begins in the diploe and is apt to produce a similar fusiform swelling, but the edges of the bony defect are likely to be more serpentine and the margins of greater density, and we would not see any tendency toward trabeculation within the area occupied by an epidermoid. On rare occasions, however, we might find it extremely difficult to make a differential diagnosis as even the history in the presence of these two conditions would be practically the same. The symptoms would merely be those of slight cortical pressure due to the inward bulging of the fusiform mass, and would vary with the portion of the cortex involved.

A bone defect due to the presence of a leptomeningeal cyst may so closely simulate either a hemangioma or an epidermoid as to be very confusing. The leptomeningeal cyst is very apt to possess daughter cysts which would produce varying grades of bone absorption about the central lesion, and as the hemangioma is almost always sharply localized this would usually permit of making a differential diagnosis, and in addition the history of a severe trauma some years prior to the examination, plus attacks of Jacksonian epilepsy, would strongly point to the lesion being a meningeal cyst.

Another condition which might at times be confusing would be a localized area of exaggerated diploe. This condition is usually not difficult to recognize because the bone will have a normal unspiculated appearance with no suggestion of osteolysis. Rarely these areas of increased diploe will present many small vascular channels passing through the inner table which may suggest honeycombing, but on close inspection the interspersed bone will be found to be of normal structure. Such areas, however, may harbor small vascular anomalies of the capillary or telangiectatic varieties but they are not bone hemangiomas. On very rare occasions a hemangioma of the meninges might invade the overlying bone and give rise to the typical spiculated appearance of a hemangioma originating in the bone. Under these circumstances we could hardly hope to be able to tell where the lesion actually originated. The symptomatology, however, may be more pronounced with a meningeal lesion; symptoms are usually slight with a hemangioma of bone.

The treatment of these calvarial hemangiomas is preferably surgical. Their removal is relatively simple and recurrence is not to be expected. Radiation in heavy doses would stop the growth of the lesion but if

FIG. 13. Aneurysm of the right internal carotid artery (same case as Fig. 14), showing the characteristic curved lines of calcification above and lateral to the atrophic sella turcica.

much bone hypertrophy had occurred we could not expect the radiation to reduce the tumefaction, hence it would not relieve the symptoms. Irradiation is not to be recommended if the hemangioma is easily accessible for surgical removal.

An aneurysm is a pulsating tumor formed by the dilatation of the walls of an artery, and so rightly belongs in a discussion of blood vessel tumors and anomalies. Bailey enlarges somewhat on the usual definition of an aneurysm found in the dictionaries and terms it a focal, fusiform or saccular dilatation of an arterial wall.

Intracranial aneurysms are rather uncommon. They are found in less than 2 per cent of all autopsies and are usually quite small and therefore asymptomatic, hence their recognition during life would be highly improbable. There are several etiological factors which may lead to the formation of an aneurysm. First, an anatomical variant in the vessel wall which weakens the muscular layer, and this may be accompanied by an abnormally small vessel on the opposite side which would tend to overload the already weakened wall. Second, in young people an aneurysm may be produced by an embolus from a rheumatic heart which would infect and weaken the vessel wall. Third, in people beyond thirty-five years of age arteriosclerosis often plays an important rôle. Fourth, trauma is an element to be considered. Fifth, syphilis may play a part although a syphilitic intracranial aneurysm is uncommon and when found is apt to involve the basilar artery.

Aneurysms can occur anywhere in the arteries of the skull and brain but by far the greater number are found involving the vessels forming the circle of Willis and their immediate branches. The lesion is almost always situated at a bifurcation and rarely will it attain a size sufficient to produce any elevation of intracranial pressure. It is at times difficult to definitely differentiate between a small aneurysm and a small hemangioma unless a careful microscopic

FIG. 14. Aneurysm of the right internal carotid artery. Note the curved double line of increased density behind the shadow of the right orbit (arrow).

study is made. This fact has undoubtedly confused the literature to some extent, but for this discussion we will confine ourselves to the larger, well-defined aneurysms which are the only ones we could hope to recognize in the roentgenogram. The clinical symptoms of an aneurysm are often very confusing and may closely simulate a tumor, so that not infrequently the diagnosis of such a lesion depends almost entirely upon the findings of the roentgenologist. It can readily be understood that a surgical attack on an aneurysm under the impression that another form of tumor is present is to be avoided if possible.

The clinical symptoms referred to above are those prior to rupture. Those following rupture are still apt to be confusing but usually include a sudden unexplained headache with some stiffness of the neck, and there are usually some neuralgic pains in the face. It is interesting to note that the arteries on the left side are more apt to be involved than are those on the right side, and the literature seems to indicate that women are more prone to suffer from intracranial aneurysms than are men.

In 1926, Sosman and Vogt, in an excellent article, set forth the cardinal points to be noted in order to make a roentgen diagnosis of an aneurysm about the circle of Willis. Their criteria have stood the test of time and but little can be added even after a lapse of about twelve years.

The smaller uncalcified aneurysms we could hardly expect to recognize in the roentgenogram, and even a careful encephalographic study would usually prove of no avail. A thorotrast injection study might help us discover a small lesion or lesions, but the chances are against the small sac becoming well enough filled during the rapid transit of the thorotrast to cast a recognizable shadow. In this connection, it would be well to mention that as the large aneurysms have a tendency to become at least partly clotted, a thorotrast injection might show a vessel lumen not greatly altered from the normal, so that in spite of an apparent normal vessel caliber, we must carefully weigh the other evidence before drawing our final conclusions.

Fig. 15. Aneurysm of the left internal carotid artery. Note the curvilinear streak of calcification above and lateral to the markedly atrophic sella turcica. (The arrow indicates the remains of the posterior clinoid processes and dorsum sellae.)

Most of the aneurysms that we are able to diagnose contain sufficient calcium to cast a shadow on the film. This shadow will usually be linear in form and arch upward above the sella turcica; this arching may also extend laterally so that one may easily estimate the size of the cyst-like dilatation because the calcium is deposited mostly in the dilated vessel walls. In well made stereoscopic films the one-sidedness of the lesion can easily be seen. If the aneurysm is very large it may bulge over the midline. Bilateral aneurysms are so unlikely as to be hardly worth considering, but such a possibility must not be entirely lost sight of.

In addition to the curvilinear calcification we will usually find some atrophy of the sella turcica which is very apt to be much more pronounced on one side. This is chiefly noted in the dorsum sellae and posterior clinoid processes, although in well-made stereoscopic films one entire side of the sella turcica may appear atrophic as compared to the opposite side. A film taken in the anteroposterior plane with the head

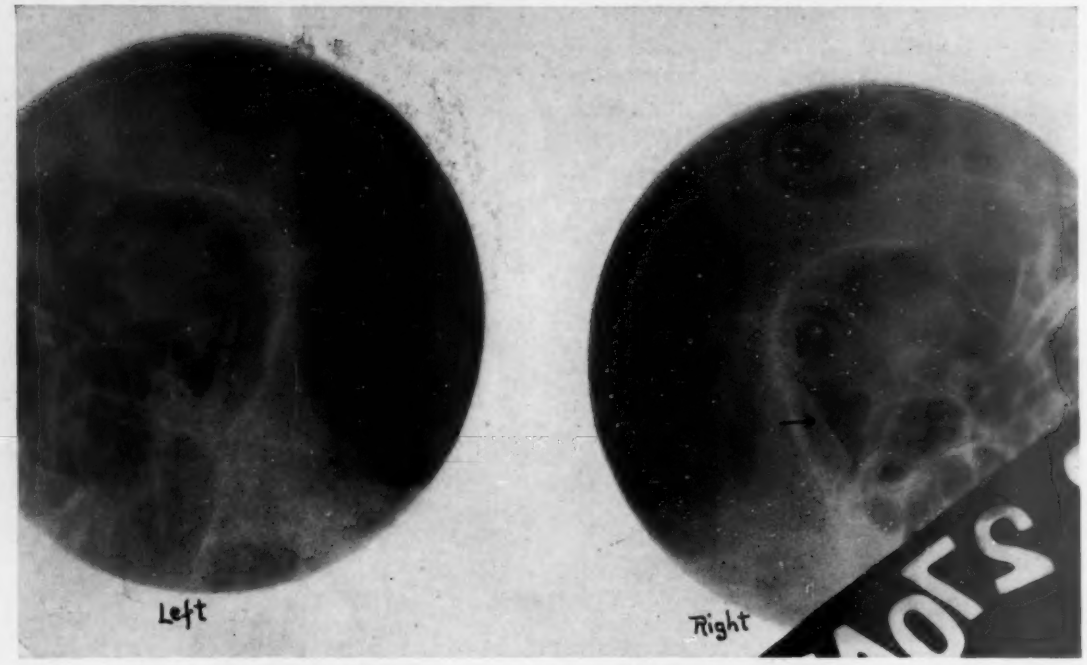

Fig. 16. Aneurysm of the right internal carotid artery which has eroded the inferior and lateral wall of the right optic canal. Compare with the normal optic canal on the left side.

tilted forward slightly, in order to throw the shadow of the dorsum sellae into the negative shadow of the foramen magnum, will often clearly show this asymmetrical atrophy.

A third condition not infrequently encountered in the presence of an aneurysm is atrophy and enlargement of the homolateral optic foramen. One must not confuse such a condition with normal asymmetry of the optic foramina or with a condition in which the optic foramen and the canal carrying the optic vessels have merged in such a manner that the optic foramen has an apparently enlarged, irregular inferior margin. A careful study of the bony structure will usually permit differentiating normal from atrophic bone.

So far, we have been discussing aneurysms about the circle of Willis. Rarely, such lesions may occur along the cerebral arteries at their numerous bifurcations. When this happens, calcification is not so apt to occur and if it did we would be much more apt to make a diagnosis of a glioma or a more benign form of vascular anomaly so that it would be the rare exception to be able to make a diagnosis of such a lesion. Those occurring in the basilar artery are not often calcified. Their presence might be indicated from a careful encephalographic study, although in spite of their position the fourth ventricle may or may not be displaced posteriorly, and in fact in many encephalograms we are unable to demonstrate the fourth ventricle. But if the lesion occurs at the bifurcation of the basilar artery we may be able to recognize it because the upper reaches of this artery are not infrequently seen in a gas-filled cisterna pontis which would, of course, be distorted and perhaps dilated in the presence of a fair sized aneurysm.

The differential diagnosis of an aneurysm of an artery about the circle of Willis usually concerns itself chiefly with the possible presence of a pituitary adenoma. The roentgen findings and in fact the symptoms can be very similar, which may at times make the diagnosis rest almost entirely upon an injection of thorotrast. If we were able to make out curved streaks of calcifi-

cation and unilateral optic foramen atrophy we could at once rule out a pituitary adenoma. It must be borne in mind that a pituitary adenoma can produce atrophy of an optic foramen. Unilateral atrophy of the sella turcica might also be caused by an asymmetrically developed pituitary tumor. Hence, when we encounter a case which seems to be a pituitary adenoma but the combined clinical and roentgen "picture" does not "ring true," we should search diligently for evidence of a possible aneurysm. Suprasellar meningiomas and gliomas would rarely be confused with an aneurysm if we pay strict attention to the history and remember the characteristics of these tumors which have been discussed in previous articles.

SUMMARY

Blood vessel anomalies and tumors together with hemangiomas of the skull bones have been discussed from the point of view of making a roentgen diagnosis, and with a brief consideration of the indications for radiation therapy. There has also been added a discussion of intracranial aneurysms. A fairly extensive bibliography has been appended for the benefit of those who may wish to pursue this subject to greater lengths.

The observant reader may have recognized some of the illustrations appearing in this article as having appeared in other articles coming from this clinic. Many of these cases have been in our teaching collection for several years and have been freely used in the past for illustrative purposes. The illustrations appearing herewith, however, are from new prints which are perhaps an improvement on those heretofore used.

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THE ROENTGENOLOGICAL MANIFESTATIONS OF PULMONARY EMBOLISM WITH INFARCTION OF THE LUNG*

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"Between the years 1846–1856 Virchow constructed the whole doctrine of embolism upon the basis of anatomical, experimental, and clinical investigations which for completeness, accuracy, and truth must always remain a model of scientific research in medicine."—WELCH

THE significance of pulmonary infarction as an entity of grave import, is recognized by all practitioners of medicine. This dangerous complication often arises out of a clear sky and may result in the sudden and unexpected death of a convalescent. The condition is quite common, perhaps more so than the average physician realizes. On the basis of vital statistics, Barnes[3] has estimated that 33,746 people die from pulmonary embolism yearly in the United States. In collected statistics from the literature, Hosoi[14] found the incidence of pulmonary embolus at autopsy to vary from 0.65 to 14.5 per cent. The incidence of postoperative emboli varied from 0.12 to 0.67 per cent. Collins[9] found the average incidence of pulmonary embolism reported by fifteen authors to be 0.53 per cent. The figure in surgical cases was 0.28 per cent, whereas in autopsy cases it was 2.68 per cent. Henderson[13] noted that pulmonary embolism was responsible for 6 per cent of all postoperative deaths at the Mayo Clinic from 1917 to 1927. From 1928 to 1933 this figure was 5.8 per cent as reported by Barker.[2] Belt[4] stated that pulmonary embolism was responsible for death in 6.5 per cent of 567 consecutive post-mortem examinations.

During the past decade a considerable number of papers on pulmonary embolism and infarction have appeared in the literature. However, there is a paucity of material dealing with the roentgenological aspects of the condition. With these facts in mind, we have reviewed a series of 18 cases of pulmonary infarction observed during the past three years in an attempt to analyze the roentgen findings, and present them in a usable manner.

GENERAL ASPECTS

There are a large number of predisposing factors concerned in the causation of pulmonary embolism. The condition is often seen in older people. In surgical cases it is most prevalent following abdominal and pelvic operations. Although pulmonary embolism is usually considered a postoperative surgical complication, in reality it is found just as frequently in medical as in surgical patients. Cardiac disease is an outstanding predisposing factor, particularly in the presence of congestive failure. Trauma, infection, dehydration, changes in the blood elements, and slowing of the blood stream, all predispose towards thrombosis and embolism. Pulmonary infarction complicating mitral valvular disease is not infrequent,[18] especially in the presence of congestive failure. McCartney[20] found that fatal pulmonary embolism was twice as common among patients who had heart disease as others. The origin and source of pulmonary emboli is commonly a thrombus in the inferior vena cava, femoral, iliac or pelvic veins. At times, emboli arise from a thrombus in the right side of the heart, especially in the presence of an auricular fibrillation.

Pulmonary infarcts are the result of occlusion of the pulmonary artery or one of its branches, and the changes are usually secondary to embolism or thrombosis within the pulmonary vessels. Although

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the source of pulmonary emboli is often in the peripheral venous circulation, it is known that primary thrombosis of the pulmonary arteries, which contain venous blood, does occur, and the occlusion may be primary in the vessels of the lung (autochthonous). Billings[5] found reports of 16 cases of "primary" thrombosis of the pulmonary artery among 6,200 autopsies.

It is quite well recognized that embolism or thrombosis of the pulmonary arteries does not always produce a pulmonary infarct, although the two conditions are often associated. In the lung, the dual blood supply from the bronchial and pulmonary arteries frequently affords sufficient collateral circulation to prevent the formation of infarcts. Also, pulmonary emboli do not always produce a complete obstruction of the vessel in which they lie. Infarction is more common when the pulmonary circulation is not adequate, as in congestive failure. Hosoi found that pulmonary infarction occurred twice as frequently following embolism in medical cases as in postoperative cases, probably because of the associated cardiovascular disease in the medical group.

PATHOLOGY

Pulmonary infarcts are dark red in color and rather firm in consistency. The portion of the lung involved is unaerated, as the air spaces are filled with red blood cells. Infarcts of the lung are often multiple and they are nearly always of the "hemorrhagic" type. They vary in size considerably. Some are as small as a hazelnut, whereas others are large enough to occupy almost the whole lobe of a lung. In the classical case these infarcts are pyramidal or wedge shaped, with the base toward the periphery of the lung. In many instances, they are grossly irregular in outline and do not conform to the typical configuration. Infarcts are usually produced by emboli of moderate size. This is probably explained by the fact that large ones occlude the main branches of the pulmonary artery and result in death before roentgenological diagnosis can be made. The embolus obstructing the pulmonary artery will be found at the apex of the infarct. Pulmonary infarcts are usually situated in the periphery of the lobe and are often associated with pleuritis. They are commonly seen in the lower lobes, more often on the right side. Aseptic infarcts may be gradually absorbed and disappear completely or they may change into a small mass of fibrous tissue. Septic infarcts may produce necrosis of the lung with the formation of a lung abscess or gangrene. If the infarction perforates the pleura, empyema may ensue.

CLINICAL FEATURES

The patient's history is of the greatest significance. Very often there has been a recent abdominal or pelvic operation. Hampton and Wharton[12] found that pulmonary infarction occurred in the second or third week after operation in 25 per cent of their cases. Occasionally there is a history of recent fracture of the long bones. Thrombophlebitis in the legs is often the source of a pulmonary infarct. Cardiac patients should always be regarded as suspects, particularly when congestive failure or fibrillation is present.

There is a considerable variation in the clinical picture, depending a great deal on the size of the artery occluded, and whether or not the block is complete. When the embolus obstructs the main pulmonary artery or one of the larger branches, death may be instantaneous. A fatal pulmonary embolus is often preceded by one or more milder attacks, since emboli are frequently multiple.

With large pulmonary emboli, the onset of symptoms is usually sudden and dramatic. Cyanosis and dyspnea are noted. In some cases there is sudden shock, and collapse of the circulatory system. The pulse is rapid and feeble, the blood pressure drops and the patient perspires profusely. At times, there is a moderate elevation of temperature with leukocytosis. The heart sounds are rapid and there is accentuation of the pulmonic second sound. In some cases there is increased pulsation in the second or third interspace to the left of the

sternum. When the infarct is fairly large in size there will be signs of pulmonary consolidation with an impaired percussion note. If the patient survives, signs of right heart failure may develop—the so-called acute "cor pulmonale."[21] The presence of engorged and pulsating neck veins is evidence of increased venous pressure. Large pulmonary emboli are usually fatal. Recovery may follow an attack of pulmonary embolism or it may result in another fatal attack. Hampton and Wharton report that 50 per cent of their patients died within thirty minutes after the onset of the pulmonary embolism; 25 per cent died within fifteen to twenty-four hours, and 10 per cent recovered. Clinically, these cases often simulate an acute coronary occlusion. Certain electrocardiographic changes have been described[5,21] which are rather characteristic of pulmonary embolism, and of value in its differentiation from acute coronary occlusion.

In milder attacks, the symptoms are less dramatic. There is dyspnea and pain in the chest, usually worse on inspiration, due to the associated pleuritis. A pleural friction rub may be detected clinically. The physical signs of consolidation are often absent with small infarcts.

Very small pulmonary infarcts may produce few symptoms or none at all. Undoubtedly, many are not recognized clinically. With small emboli, there may be slight pain in the chest or substernal discomfort. In some cases there is a slight cough and a few râles are heard in the chest. The presence of blood-tinged sputum, when present, is extremely helpful in arriving at the proper diagnosis.

ROENTGEN DIAGNOSIS

It is a recognized fact that there are many inherent difficulties associated with the roentgen diagnosis of pulmonary infarction. In the first place, infarction need not necessarily follow embolism, nor does it always follow. Consequently, one must expect the roentgen examination of the lungs to be negative in a moderate number of clinically recognized cases of pulmonary embolism. It is only when infarction of the lung takes place that we may obtain secondary roentgen evidence of the presence of a pulmonary embolus, which itself is not demonstrable. Secondly, an examination made just after the onset of an attack may reveal no evidence of infarction, whereas a film made a few days later will reveal the infarct quite readily. Also, many of these patients are very acutely ill, and the roentgen examination is usually made at the bedside with a portable unit, under unfavorable technical circumstances.

Kirklin and Faust[16] state that "it is difficult, and at times impossible to make a diagnosis of pulmonary infarction from the roentgenogram. With the clinical data, however, the nature of the shadows appearing on the film may usually be accurately determined." Stewart[24] and Sante[22] in discussing this paper admit difficulty in the roentgen demonstration of pulmonary infarcts. Assmann[1] implied that he has demonstrated few infarcts with the roentgen ray. Farr and Spiegel[10] observed that many cases are not recognized. They report 23 cases with roentgen examinations, but in only 5 were the roentgen findings suggestive of pulmonary infarction.

Kohlmann[17] and Wharton and Pierson[27] were among the first to present a detailed discussion of the roentgen diagnosis of pulmonary infarction. Kohlmann concluded that in many cases the roentgen appearance of pulmonary infarction is recognizable, and that it may be of great diagnostic aid in atypical clinical cases.

From the study of our own cases and a review of the literature, we are convinced that pulmonary infarcts present a considerable variation in their roentgen appearance. When typical they appear as pyramidal or wedge-shaped areas of increased density with their bases towards the periphery of the lobe, but only a small proportion of infarcts show the typical pyramidal form. Many present shadows of indefinite and irregular outline, and one should not rely on the presence of the typical pyramidal shadow for diagnosis. Kirklin and Faust point out that there is

frequently so much surrounding inflammation that an infarct may not be distinguishable from a pneumonic process.

In some instances the shadow of the infarct is round or oval.[17] In these, the plane of the infarct and apex is directed sagittally, with the base toward the anterior or posterior chest wall. A lateral view of the chest may reveal the pyramidal nature of these shadows which appear round or oval as a result of the angle or projection of the roentgen beam.

Wharton and Pierson found the first notable change in pulmonary infarction to be a clouding of the costophrenic angle, often seen within twenty-four hours after the onset. With large emboli, areas of increased density appear at the base of the lung, the margins of which are very clearly defined. The shadows of infarcts are not as dense as those seen in pneumonia. Associated pleural changes take place and become very marked.

Camp[8] has called attention to the accentuation of the hilar shadow on the side of the embolus. This is evidently due to the dilatation of the pulmonary vessels on the affected side. Fowler[11] mentions a case of complete thrombotic occlusion of the right pulmonary artery, and a partial occlusion of the left. The roentgenogram of the lungs showed only a prominence of the hilar shadows. Boswell and Palmer[7] report a case of primary progressive thrombosis of the right pulmonary artery. Roentgen examination of the lungs showed increased density of the shadow of the pulmonary artery, but its significance was not realized until the post-mortem examination. The large normal variation in the density of the hilar shadows and pulmonary vessels should always be borne in mind, when attaching significance to the point.

It is well known that pulmonary infarction occurs frequently in lungs with chronic passive congestion. In these cases, there is very little difference in density between the infarct and the congested lung, and detection of the former is extremely difficult. Wessler and Jaches[26] stated that not every extensive shadow in the lung in cardiac disease should be considered an infarct, since pneumonias do occur, which are often terminal.

At times, the shadow of the infarct is obscured by an associated pleural effusion resulting from the pleuritis accompanying the infarct. The roentgen examination in these cases may reveal the effusion, whereas the shadow of the infarct is completely masked by the fluid. In these instances, the patient's history will often allow one to surmise the presence of the primary lesion.

Aseptic infarcts usually heal quite readily and often disappear completely. In some cases, a few fibrous strands or residual pleural thickening is noted at the site of infarction. Septic pulmonary infarcts may produce necrosis of the lung and result in abscess formation or gangrene of the lung. In such instances, localized areas of rarefaction will be noted within the shadow of the infarct. The presence of a fluid level within the area of infarction presents confirmatory evidence.

Evidently there is a considerable variation in the persistence of shadows representing infarcts, and we have been interested in the duration of the shadows particularly as a possible aid in the diagnosis of obscure cases. According to Kerley,[15] "A pulmonary infarct tends to clear up very rapidly. In six cases, the lesion had either vanished or diminished in size by two thirds over a period of a fortnight." Wharton and Pierson observed that the lung cleared in ten to fourteen days, but the pleural changes persisted a great deal longer. Kohlmann did repeated roentgen examinations on a patient over a period of several months but found very little change in the appearance of the shadow. At autopsy, an infarct was found in the area suspected. The persistence of roentgen shadows for several months and even years has been mentioned in the literature.[10] In those cases where the shadow of the infarct persists over a long period, organization of the infarct has probably occurred. At times, linear shadows are noted in the roentgenogram representing scars of healed

infarcts.[23] In some cases, the only remaining evidence is residual pleural thickening or adhesions. It seems, then, that the shadows representing infarcts may vary a great deal in duration. Large infarcts and those accompanied by considerable pleural reaction persist the longest. We have found small infarcts to resolve rather quickly, even within a period of a few days. It is our impression that the shadows representing infarcts resolve slower than patches of pneumonia of the same size.

In one of our cases, serial examinations of a large pulmonary infarct were made and it was found that resolution of the infarct took place at the periphery of the lesion, with a gradual diminution in the size of the infarct. This point, if confirmed, may be of value in the differentiation from pneumonia. In most instances, pneumonia infiltration resolves in a rather uniform manner throughout, rather than at the periphery of the involved area. The differentiation of infarct from pneumonia is not always possible at the initial examination. Recently we observed a faint, well-defined, triangular shadow on the roentgenogram. The roentgen appearance was more suggestive of a lung infarct than pneumonia. Subsequent roentgen examination showed the infiltration to be larger in size and irregular in outline and quite characteristic of pneumonia. Clinical and laboratory studies established the diagnosis of lobar pneumonia, Type II. The triangular shadow is not pathognomonic of a pulmonary infarct, and in fact is found in a minority of cases.

In reviewing our films, we found that pulmonary infarction was often associated with a moderate elevation of the diaphragm on the affected side. The change is probably produced by the pleurisy which so often accompanies infarction, with resulting splinting and restriction of diaphragmatic excursion. This phenomenon is particularly noted when the infarct is situated in the lower lobes.

There are a number of conditions which may simulate pulmonary infarction roentgenologically. The patient's history is extremely significant, and usually presents the clue to the diagnosis. Kerley demonstrated an infarct in the infraclavicular portion of the lung which simulated an incipient tuberculous lesion. Small patches of pneumonia offer the greatest difficulty in differential diagnosis. Wharton and Pierson believe the shadows of pneumonia are not as clearly defined, and pleural reaction is not as marked as in pulmonary infarction. The shadows representing early lung abscess, neoplasm, interlobar effusion, and cysts, should be considered in the differential diagnosis.

TREATMENT

At the present time, more and more emphasis is being placed on the prevention of pulmonary embolism and infarction. Elective surgery should be discouraged in the aged and in patients with severe cardiac disease. In postoperative cases, various procedures have been proposed to prevent venous stasis, such as heat and massage to the extremities. For the treatment of an acute attack of pulmonary embolism, various antispasmodics such as papaverine have been used. Morphine is valuable for pain, restlessness, and dyspnea. Oxygen may be administered for cyanosis. Absolute bed rest and quiet are imperative. The Trendelenburg operation (pulmonary embolectomy) has been advocated, but its use has not been extensively employed.

CONCLUSIONS

The following data are presented as a résumé of the findings concerned with the roentgenological diagnosis of pulmonary infarction.

1. The roentgen evidence of a pulmonary embolus is usually absent, unless infarction of the lung takes place.

2. The shadow of an infarct may be absent early, and not appear for several days after the onset of a pulmonary embolus.

3. Accentuation of the hilar shadows and pulmonary vessels on the affected side.

4. Clouding in the region of the costophrenic sulcus.

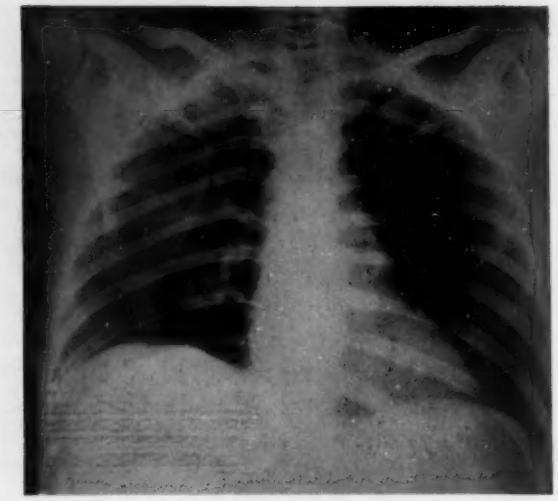

FIG. 1. Case I. Typical triangular-shaped infarct in the right upper lobe secondary to a thrombophlebitis of the left leg.

5. Triangular, round, oval, or irregular shaped shadows in the lung.

6. Elevation of the diaphragm on the affected side.

7. Resolution of the infarct at the periphery of the lesion in some cases.

8. Evidence of associated pleurisy.

9. Localized rarefaction indicating necrosis or abscess formation.

10. Pleural thickening and localized fibrosis as evidence of old infarcts.

11. Infarcts are distinguished with difficulty in chronic passive congestion of the lungs.

12. An associated pleural effusion, when present, may mask the shadow of the infarct.

13. A prominence of the pulmonary conus, with evidence of right ventricular enlargement may be noted in "cor pulmonale," if right-sided heart failure is present.

14. There is considerable variation in the roentgen appearance of pulmonary infarction.

SUMMARY

The clinical, pathological, and roentgenological features of pulmonary infarction are described. The material presented is based on a review of eighteen cases, including pertinent observations noted in the literature. The roentgen diagnosis is emphasized.

CASE REPORTS

CASE I (9764). E. C., female, aged forty-four. This patient had a thrombophlebitis of the left leg and gangrene of the left foot of two months' duration. She suddenly complained of severe pain in the chest, which was followed by the expectoration of blood-streaked sputum. Roentgenogram of the lungs revealed a faint triangular shadow of increased density on the right side at the level of the second anterior interspace. The right leaf of the diaphragm was elevated. The roentgen appearance was typical of a pulmonary infarct (Fig. 1). The patient died.

CASE II (14340). R. W., male, aged fifty-one. Four days following an operation for suppurative osteomyelitis of the sternum, this patient complained of pain in the chest, and expectorated blood-streaked sputum. Blood culture was positive and revealed a *Staphylococcus albus* septicemia. Roentgenogram of the lungs demonstrated an irregular patch of infiltration in the left lung which represented a septic pulmonary infarct (Fig. 2). The following day the patient died.

CASE III (10303). W. M., male, aged thirty-four. Eighteen days following an operation for a ruptured appendix, this patient complained of pain in the right chest. At this time blood-streaked sputum was noted, which persisted for several days. Roentgenogram of the lungs revealed a shadow of increased density just above

FIG. 2. Case II. Septic infarct of the left lung from a suppurative osteomyelitis of the sternum with positive blood culture.

the right leaf of the diaphragm, the roentgen appearance of which was consistent with a pulmonary infarct situated in the right lower lobe. There was also a slight elevation of the right leaf of the diaphragm. The patient recovered.

Case iv (13603). W. C., male, aged fifty-nine. This patient was admitted to the hospital complaining of pain in the left chest and dyspnea. He had previously had a coronary occlusion with positive electrocardiographic findings. The clinical diagnosis was pulmonary infarction secondary to an old mural thrombus of the heart. Roentgenogram of the lungs revealed a

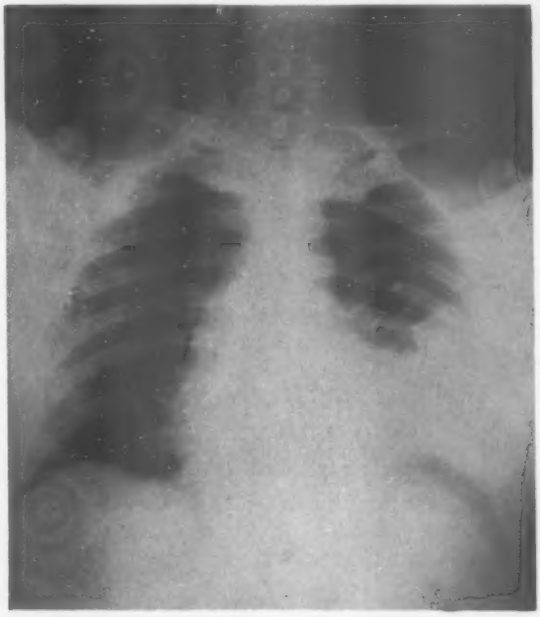

Fig. 3. Case iv. Infarct of the left lower lobe with small pleural exudate following a coronary occlusion.

large shadow in the left lower lobe consistent with an infarct. A small pleural exudate was noted in the region of the left costophrenic sulcus (Fig. 3). Re-examination two weeks later showed almost complete resolution. The left leaf of the diaphragm was elevated and fixed on respiration as a result of diaphragmatic adhesions. The patient recovered.

Case v (12617). R. P., male, aged twenty-eight. Eleven days following an operation for acute suppurative appendicitis, this patient complained of cough and pain in the chest. Blood-streaked sputum was noted for several days. Sputum examination was negative for pneumococci and tubercle bacilli. Roentgeno-

Fig. 4. Case v. Oval-shaped infarct in the right lower lobe following operation for acute suppurative appendicitis.

gram of the lungs revealed an oval shadow of increased density adjacent to the right leaf of the diaphragm. The roentgen appearance was consistent with an infarct in the right lower lobe (Fig. 4). Two weeks later the patient began to complain of pain in the left chest. Roentgen examination revealed a second infarct in the left lower lobe. At this time the infarct pre-

Fig. 5. Case vi. Large infarct secondary to thrombophlebitis involving both legs.

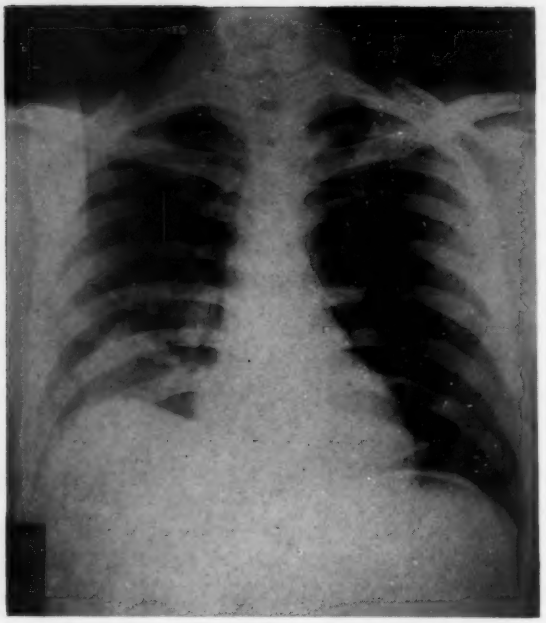

FIG. 6. Case VI. Same case one month later. Infarct is much smaller in size and has a typical triangular configuration.

viously noted in the right lower lobe had completely resolved and disappeared. The second infarct also resolved completely, and the patient fully recovered.

CASE VI (13980). T. B., male, aged forty-two. This patient was admitted to the hospital with a thrombophlebitis involving both legs. Five days later he complained of cough and severe pain in the right chest. Roentgenogram of the lungs revealed a dense shadow in the right lower lobe with a convex upper border. The right leaf of the diaphragm was elevated. The roentgen appearance was consistent with a large pulmonary infarct (Fig. 5). Re-examination one month later revealed a marked decrease in the size of the infarct which now appeared triangular in outline (Fig. 6). A subsequent roentgen examination seven weeks later showed almost complete resolution, and the patient was discharged well.

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PRIMARY SARCOMA OF THE BRONCHUS*

CASE REPORT

By BERTHOLD S. POLLAK, M.D., SAMUEL COHEN, M.D., MILTON G. BORRONE, M.D. *and* ANGELO M. GNASSI, M.D.
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REVIEW OF LITERATURE

PRIMARY sarcoma of the laryngotracheobronchial tree is a rare condition.

New,[1] in reviewing the records over a twenty-five year interval (1910–1935) at the Mayo Clinic, noted only 6 cases of sarcoma of the larynx in contrast to 800 patients with carcinoma of the same organ. He commented that the former were, as a rule, clinically benign and reported 2 cases treated by him surgically—a fibrosarcoma and a chondrosarcoma.

D'Aunoy and Zoeller[2] found 350 cases of primary tracheal new-growths mentioned in the literature up to 1930. Of these, 26 were tracheal sarcoma including 3 of their own: spindle cell, round cell and fibrosarcoma.

Vinson,[3] in a ten-year period at the Mayo Clinic (1925–1935), stated that a diagnosis of primary malignant disease of the tracheobronchial system was made from histologic study of biopsy specimens in 140 cases: squamous cell epithelioma, 76; adenocarcinoma, 59: undifferentiated carcinoma, 3; ungraded carcinoma,1; lymphosarcoma, 1.

Rarest of all is a primary bronchial sarcoma. We have not been able to find a single bona fide case described on post-mortem examination. The earliest reference that we noted in the literature to a sarcoma observed bronchoscopically was made by Kahler[4] in 1911 in an address entitled "Indications and contraindications of bronchoscopy and esophagoscopy," and delivered before the International Laryngorhinological Congress in Berlin. A patient, on direct tracheoscopy, showed a mass completely obstructing the right bronchus. He subsequently coughed up a large piece of tissue and a histological diagnosis of myxosarcoma was made. Despite further bronchoscopy and use of the cautery, the tumor recurred. The clinical record was meager and unaccompanied by photomicrographs.

Clerf,[5] in his extensive experience, stated that he had never seen a case of primary sarcoma of the bronchus either at bronchoscopy or at necropsy.

Jackson[6] made mention of 6 cases of sarcoma of the lung in which were noted endobronchial intrusion, the diagnosis being made by biopsy. Two were round cell sarcoma, 2 lymphosarcoma, 1 a giant cell sarcoma and the other a spindle cell tumor. To repeat, Jackson considered these to be peribronchial or parenchymal growths seen after endobronchial invasion and therefore not true primary bronchial sarcoma. Incidentally, it is a well-known fact that an anaplastic bronchial carcinoma, in which the cell usually assumes a round, spindle or oat shape, has often been erroneously diagnosed in the past as sarcoma. Also, according to the old terminology, a giant cell sarcoma, in the light of our present-day knowledge, may have been a sarcoma, or a carcinoma, or a chronic inflammatory process.

We believe that our case represents an authentic instance of a primary bronchial fibrosarcoma, diagnosed bronchoscopically and substantiated by careful study of the microscopic sections obtained from biopsy specimens. A complete clinical protocol and instructive roentgenograms are submitted in addition.

CASE REPORT

L. G., white male, aged nineteen, was referred to the Tuberculosis Service on July 22, 1936, by Dr. R. F. Sell of Rahway, N. J.

* From the Tuberculosis Service and the Departments of Otolaryngology and Pathology of the Medical Center, Jersey City, New Jersey.

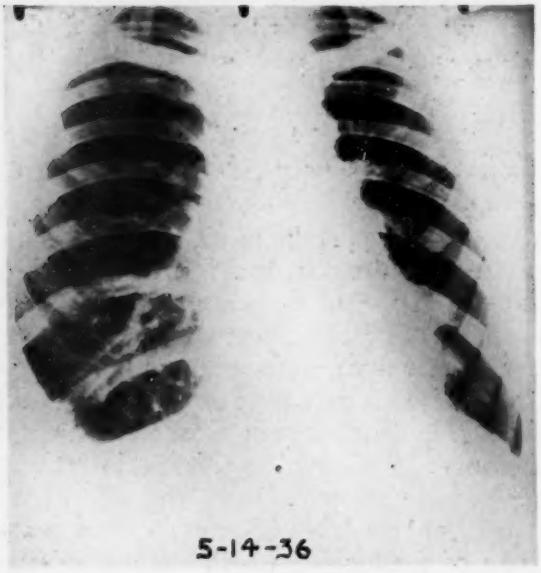

FIG. 1. Density at right base due to faulty technique and not to any pathological process.

Past History. Had measles at the age of six and tonsillectomy at seven years with no complications.

Present Illness. Patient noticed wheezing in chest in November, 1935; in January, 1936, fatigability appeared; by March, pain in chest, fever, cough developed and at the time of admission he expectorated about 2½ ounces of nonfoul purulent sputum; no hemoptysis; loss of 20 pounds since March.

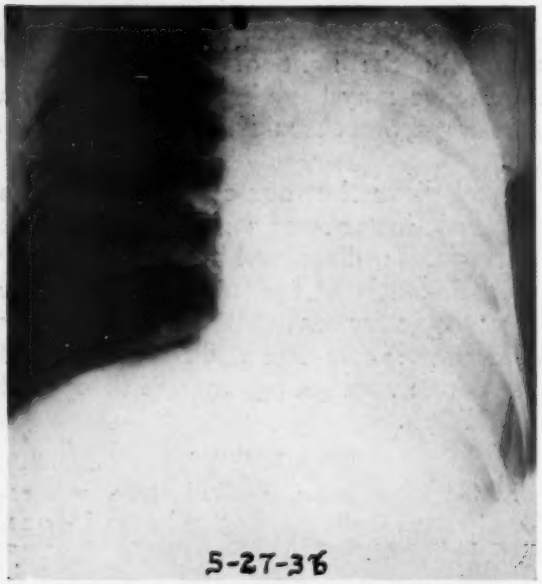

FIG. 2

Physical Examination. On entrance to the hospital, the patient was chronically ill appearing; temperature 102°F. The trachea was deviated to the left. The left lung showed marked dullness to flatness throughout, with bronchial breathing in the supraclavicular fossa and bronchovesicular breathing below the clavicle; elsewhere the breath sounds were markedly diminished to absent with corresponding changes in tactile fremitus. The right lung was negative. The heart was displaced to the left, the sounds

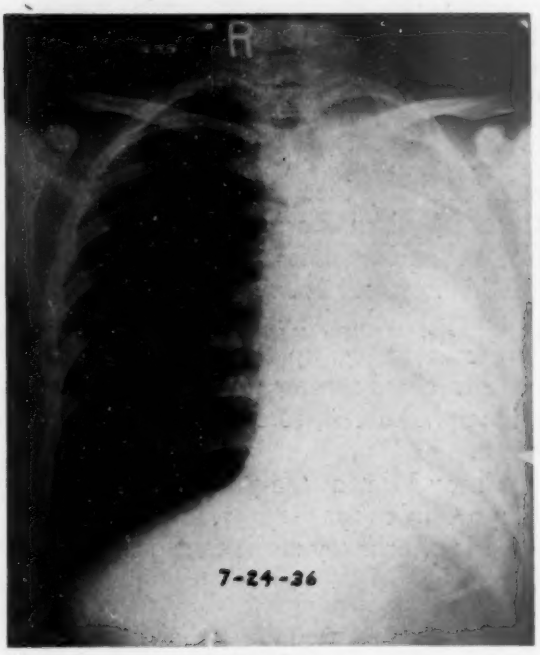

FIG. 3

regular but a pleural pericardial friction rub was audible at the apex. The extremities showed slight cyanosis of the nails but no clubbing of the fingers.

Laboratory Data. On admission, a moderate secondary anemia was noted with a leukocyte count of 20,000 and 85 per cent polymorphonuclear cells. Kolmer reaction, 2 plus; provocative test 4 plus (patient later admitted exposure). Spinal fluid serology, negative. Blood chemistry findings and urine examination were within normal limits. Seven concentrate sputum examinations were negative for tubercle bacilli. The roentgenogram of the chest (July 24, 1936) (Fig. 3) showed almost complete obliteration of pulmonary markings on the left with marked retraction of the heart and trachea to the same side; the right lung was negative.

Clinical Course. Antisyphilitic treatment was

instituted in August. At bronchoscopy on August 4, 1936, the left main bronchus was found to be obstructed 1 inch below the bifurcation of the trachea by a soft spongy mass the size of a hazel nut; remainder of bronchial tree, normal. The biopsy showed strands of fibrosis and inflammatory areas. Our plan of treatment was to remove as much of the obstructing tissue as possible and also by repeated biopsies to obtain a more definite histological diagnosis. At bronchoscopy on August 16, a piece of tissue about

Fig. 4

2.0×0.5 cm. was removed from the same site. Immediately, the patient stated he had more "breathing space." A roentgenogram showed some re-aeration of the left lung. Bronchoscopic examination repeated on August 31 revealed the former site of the tumor to be clear but directly on the opposite aspect, that is, on the anterior wall of the left main bronchus, a small mass was observed about ½ inch from the carina and measuring about 0.75 cm.×0.5 cm. This was removed and the bleeding that followed prevented further manipulation. A bronchogram (September 4) (Fig. 4) showed cylindrical and saccular bronchiectasis present in the left upper and lower lobes; definite puddling of lipiodol was seen in the trachea near the bifurcation and at the site of obstruction. The patient was placed on postural drainage. On September 10, bronchoscopy showed, at the locus of the original tumor, a piece of tissue

Fig. 5

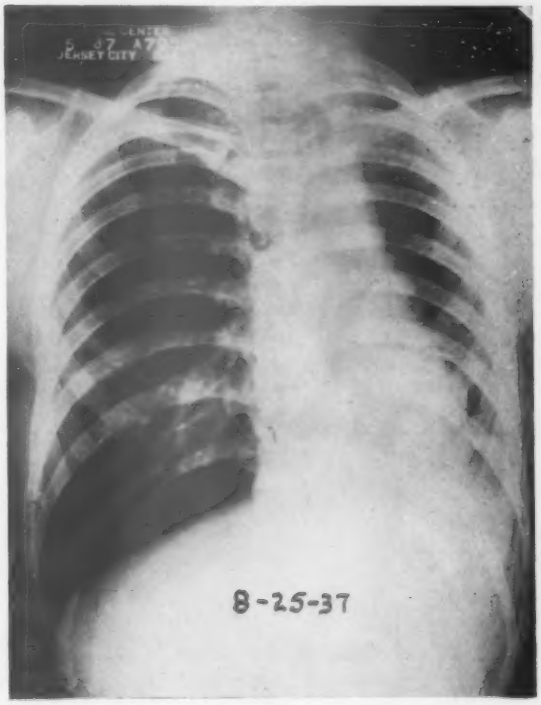

Fig. 6

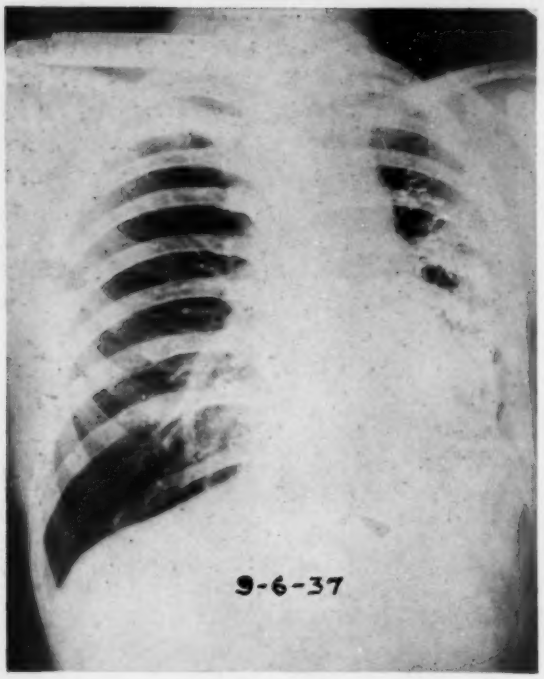

FIG. 7

measuring approximately 0.75×1.5 cm. Part of this was removed and the remainder subjected to fulguration. On September 22 and October 13 the observations were identical. The bronchial mucosa was clean, white and smooth at the region of cauterization and no residual tissue was seen. The patient's sputum at this time was reduced to ½ ounce. The roentgenogram (October 5, 1936) (Fig. 5) showed much reaeration of the left lung with patchy areas of infiltration; the heart and trachea were still deviated to the left, however. The general condition of the patient was very good. Weight on admission, 124 pounds; on discharge (October 27, 1936), 143 pounds.

Microscopic examinations of the biopsy specimens of August 31 and September 10 disclosed the following (Figs. 8, 9, 10 and 11): The mucosa was composed of pseudocolumnar epithelium with occasional mucus or goblet cells, limited by a partially fragmented basement membrane. The stroma was a loose fibrous tissue with many congested blood vessels and sprinkled with round cells. The tumor was composed of chaotically arranged bundles of spindle shaped cells. The cytoplasm was light pink, the nuclei moderately hyperchromatic and infrequently in a state of mitosis. The supporting tissue was scanty and hardly discernible. The tumor was permeated by a moderate number of blood spaces lined with endothelium and with a conspicuous muscular coat in the medium-sized vessels. Infrequent transition to a loose myxomatous tissue was noted.

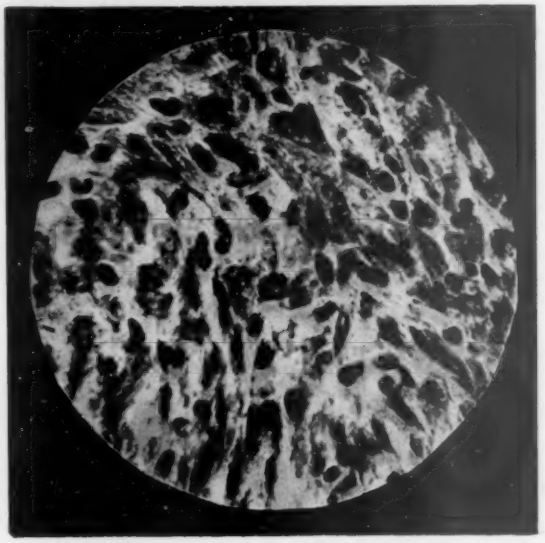

FIG. 9 (×450). Cellular mitosis.

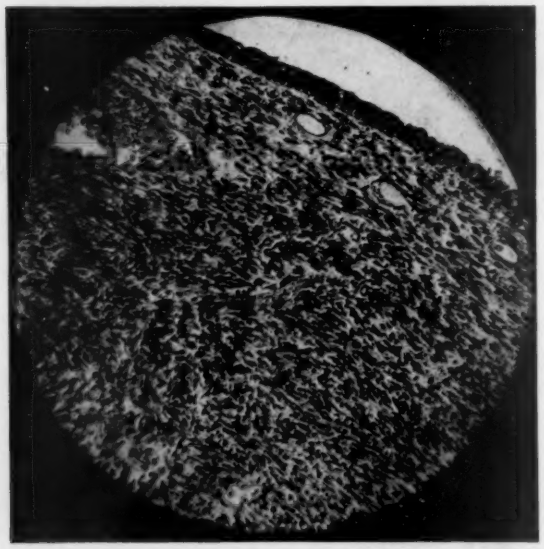

FIG. 8 (×100). Closely related cellular bundles and scanty stroma.

Diagnosis: Fibrosarcoma of bronchus. It was considered as locally malignant and, if properly removed, should not recur. This diagnosis was confirmed by Dr. Frederick W. Stewart, Pathologist of Memorial Hospital, New York City, who mentioned its histological similarity to a sarcomatous nasal polyp.

Follow-up Examinations. December 10, 1936: Bronchoscopy revealed no evidence of any tumor. No change in pulmonary status on roentgenogram. Expectoration amounted to 1–2 drachms of mucopurulent sputum daily. General condition was good. Weight 162 pounds. March 12, 1937: Bronchoscopy showed a slightly wrinkled appearance to the left main bronchial wall at the old site of the tumor. The roentgenogram (March 13) revealed further re-expansion of the left lung with persistence of mottled infiltration; mediastinum displaced to the left. Expectoration, ½ ounce daily. Weight 155 pounds. June 11, 1937: Bronchoscopic findings same as noted above; no change in roentgenogram. Expectoration about 2 drachms daily of non-foul thin sputum. September 3, 1937: Bronchoscopy showed a white scar on the bronchial wall at the site of previous manipulation; no masses noted. For the past week, the patient complained of mild pains in the chest and dyspnea on moderate exertion. Weight 148 pounds. Physical examination of the chest at this time disclosed the following: Left lung with marked dullness throughout with coarse râles anteriorly from supraclavicular fossa to fourth interspace and bronchovesicular breathing below the clavicle; diminished breath sounds in axilla with few crackling râles in the lower two-thirds; posteriorly, the breath sounds were distant except at the apex and scattered râles in both lobes were heard. The apex beat of the heart was in the fifth interspace, 4½ inches from the mid-sternal line; sounds of good quality (see Figs. 6 and 7).

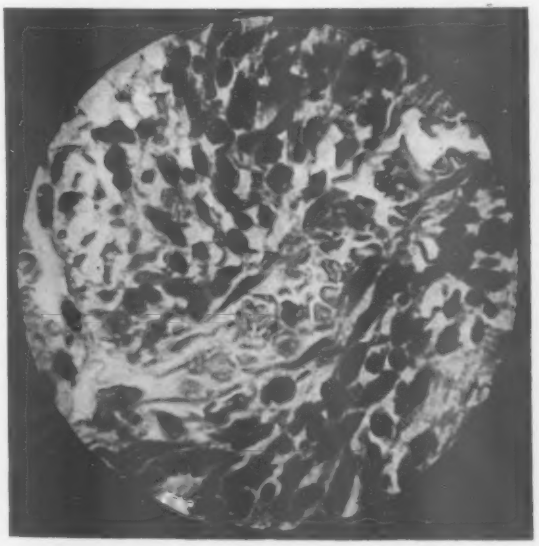

Fig. 10 (×450). Blood vessel surrounded by tumor cells.

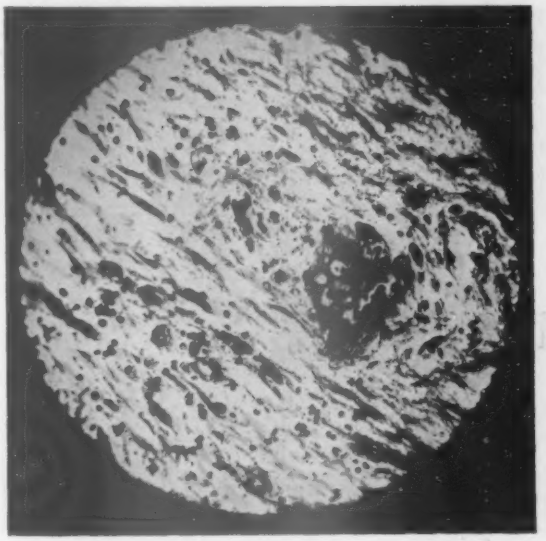

Fig. 11 (×200). Transition into myxomatous tissue.

The patient will continue to report for further examinations.

Addendum. The patient re-entered the hospital for his last check-up examination on February 27, 1939 and was discharged March 2, 1939. He felt well and had been working as a carpenter for the past nine months. Expectoration of sputum amounted to about 1 drachm daily. The patient stated he was not short of breath even while doing his manual work. His general appearance was very good and the weight was 161 pounds. The physical findings in the thorax were unchanged. No clubbing of fingers present.

Bronchoscopic examination, February 28, revealed no recurrence of any tumor mass—some narrowing of the lumen at the former site was noted. The roentgenogram of March 1, 1939, showed slight additional re-expansion of the left lung as compared to the film of August, 1937; the parenchymal infiltration was unchanged and slight residual lipiodol was still present at the base. The bronchogram of March 1, 1939, revealed no very significant change in the bronchiectatic lesion.

COMMENT ON CLINICAL FINDINGS

The history of wheezing and the physical signs in the left lung with retraction of the heart and trachea were very significant. On admission, a clinical diagnosis of obstruc-

tion of the left main bronchus probably due to a benign tumor was made. The fever and the elevated leukocyte count were attributed to pulmonary infection and to inflammation of the mediastinal pleura and parietal pericardium. The pleural-pericardium friction rub disappeared after twelve days.

We were fortunate in obtaining from Dr. Sell copies of chest films taken by him prior to the patient's entry to the Medical Center. The first film of May 14, 1936 (Fig. 1), showed the left lung to be smaller in volume than the right with some displacement of the heart to the left. The second roentgenogram, May 27, 1936 (Fig. 2), revealed a homogeneous density almost completely obliterating the pulmonary markings (left) with considerably more retraction of the heart, indicating that the previous partial obstruction had been converted into a complete obstruction of the main stem bronchus. The film on admission in July was similar. However, the roentgen density did not signify atelectasis solely, for lipiodol, September 4, 1936 (Fig. 4), outlined cylindrical and saccular bronchial dilatations in both lobes, a constant sequel to chronic bronchial occlusion, regardless of the nature of the obstructing agent. Also, after removal of the tumor, abnormal infiltration persisted on the roentgenogram one year later (August 25, 1937) (Fig. 6). A tiny amount of retained lipiodol was visualized in the fifth anterior interspace (left): the heart and trachea were still displaced to the left and the diaphragmatic contour was irregular. The pathological changes affecting the left lung are undoubtedly those of low grade pneumonitis, adhesive pleuritis, bronchiectasis and pulmonary fibrosis; changes which most likely are permanent and irreversible in this case. The bronchogram on September 6, 1937 (Fig. 7), again revealed extensive bronchiectasis, now of the predominantly "dry type" clinically. Despite the patient's present excellent general condition and leaving aside for the moment the possible recurrence of the growth, he may be subject in the future to exacerbations of the residual pulmonary infection.

SUMMARY

A rare case of a primary bronchial fibrosarcoma in an adolescent was diagnosed from biopsy specimens. Most of the tumor was extirpated by means of the bronchoscope and the residuum treated by fulguration. After a follow-up of one year, there has been no recurrence of the tumor. The interesting clinical and roentgenological features are discussed.

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Vol. 41, No. 6

DISEASES OF THE PLEURA*

By A. F. TYLER, B.Sc., M.D.
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THE more frequent diseases of the major pleural sac—effusions and empyemas—have been recognized since the earliest use of roentgen rays for study of the chest. On the other hand, recognition of the diseases affecting the various folds of the pleura along the lung fissures is of much later date and even today has received but little mention in the texts and current literature of radiology.

Barjon was the first to stress the importance of roentgenoscopic study of the lung fissures and his monograph "Radiodiagnosis of Pleuropulmonary Affections"[1] stands today as one of the best references containing, as it does, the fundamental principles of roentgen diagnosis based upon anatomical and physical findings. Since modern technique makes instantaneous lateral roentgenograms of the chest possible, certain refinements in diagnosis have become possible which could scarcely be expected when the roentgenologist was limited to fluoroscopy. Some of these diagnostic signs we may study with benefit.

ANATOMY

The right lung usually having only three lobes has one fissure between the upper and middle lobes which extends from the lung root forward almost horizontally to the anterior chest wall at the level of the third rib anterior (see Figs. 19 and 20).

The description in the anatomical textbooks locates this fissure at the level of the fourth rib anterior. It seems to us the difference in the anatomical textbook location and that in living patients is a slight difference due to the changes in the lung with some absorption of air occurring after death and with the patient examined in the dorsal position, as compared with the roentgen examination which is made in the living with the lungs filled with air in deep inspiration and in the upright position.

Another fissure is found between the middle and lower lobes extending from the lung root downward and forward to the anterior chest wall just above the diaphragm. This fissure is the one where interlobar effusions are most often found.

FIG. 1. Case No. 42185. Anteroposterior view—patient upright—of fluid in right major pleural sac. Note obliteration of the costophrenic angle by liver density, the upper margin of which is concave and high in the axilla—curve of Damoiseau.

A continuation of this fissure from the lung root upward and posterior to the level of the second dorsal vertebra is called the superior fissure. The fissure between the upper and lower lobes on the left side follows pretty closely a line drawn on the

*Read at the meeting of the Nebraska State Radiological Society, Omaha, December 9, 1937.

FIG. 2. Miss J. Case No. 5245 I.H. Anteroposterior view—patient lying with right side up. Note clear costophrenic angle and normal parenchyma with fluid density along spine. Special position used in patients too ill to be erect.

outside of the chest, extending obliquely downward, outward and forward from the second dorsal vertebra to the sixth rib anterior.

The pleura covering the medial aspect of both lungs constitutes the lateral margins of the mediastinum. These surfaces occasionally become diseased, which may then result in the formation of fluid in the mediastinum which may be either in the posterior or anterior mediastinum.

PATHOLOGY

The most common location of fluid is in the major pleural sac, between the chest wall and the lung, but often fluid may occur between the fissures of the lungs or even in the mediastinum. In any of these locations the fluid may be sterile or purulent, i.e., a simple effusion or an empyema. Empyema is more common in the major pleural sac, usually free in the sac but occasionally encysted due to adhesions forming between the parietal and visceral layers of the pleura around the purulent fluid, thus keeping it within certain narrow bounds.

On the other hand, the fluid between the lobes is more often a simple effusion than an empyema. In Type VII pneumonias there seems to be a preference of location in the lobe near the margin of one of the fissures (see Figs. 19–24). Certain roentgenological findings to be discussed later enable one to differentiate this type of pneumonia from fluid between the lobes.

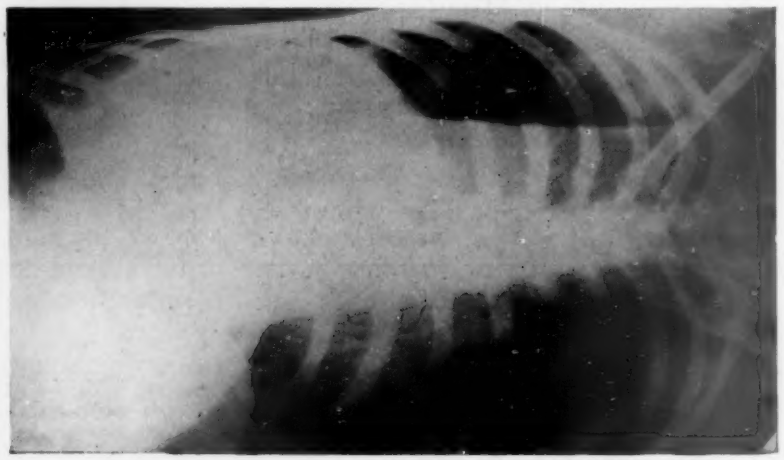


FIG. 3. Miss J. Case No. 5245 I.H. Anteroposterior view—patient lying with right side up—after withdrawal of some fluid and entrance of air. Note clear costophrenic angle, absence of parenchymal markings and fluid level near spine.

PHYSICAL FINDINGS

In fluid in the major pleural sac, flatness on percussion, shifting with change of patient's position and absence of breath sounds are classical. On the other hand, fluid between the lobes of the lungs gives practically no physical findings. Sometimes, where the fluid comes close to the surface, slight change in percussion note or breath sounds can be detected, especially if the clinician has studied the roentgenograms before re-examining the patient.

ROENTGEN FINDINGS

Fluid in the major pleural sac can be readily detected by: (1) obliteration of the costophrenic angle by liver density; (2) the density, when the patient is upright, shows a concave upper surface from the heart shadow outward and upward, highest in the axilla—the "curve of Damoiseau"; (3) film of the patient made in the anteroposterior direction while the patient lies with the suspected side upward will show clearing of the costophrenic angle and shifting of the density from the lateral margin of the lung field to the vertebral border (Fig. 2); (4) at the same time, the parenchymal markings of the lung may be seen, where in the upright position they were obscured by the dense shadow of the fluid.

Fig. 4. Case No. 40227. Anteroposterior view—patient erect—showing liver density in the lower half of the left lung field with fluid level characteristic of air and fluid in major pleural sac.

Fig. 5. Case No. 37182. Anteroposterior view—patient erect. Note localized area of liver density in right lung field near posterolateral border, the medial aspect of which shows a convex border surrounded by air-filled lung characteristic of encysted fluid in the major pleural sac.

Encysted fluid in the major pleural sac shows on the roentgenograms as an area of liver density with convex borders pushing into the lung field from the chest wall around which the air-filled lung may be seen. The costophrenic angle is unchanged and the fluid does not shift position when the patient changes position (see Fig. 5).

Fluid between the lobes of the lung can scarcely ever be detected by films made in the posteroanterior direction but can readily be seen in the lateral view with the film on the affected side. In the postero-

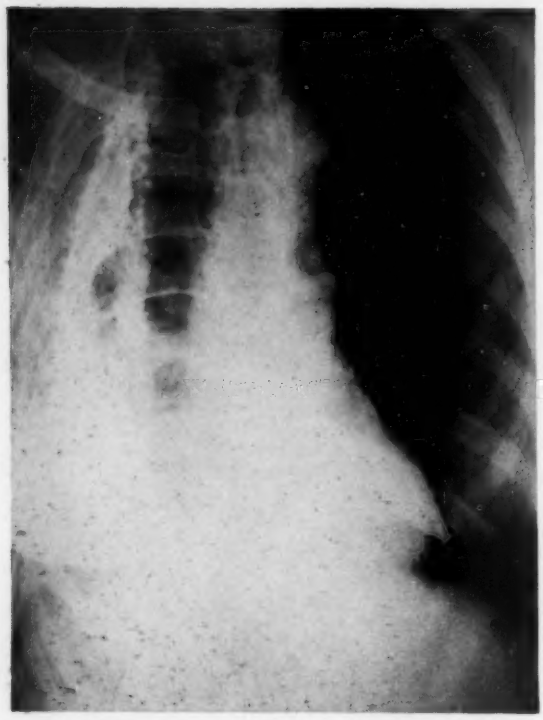
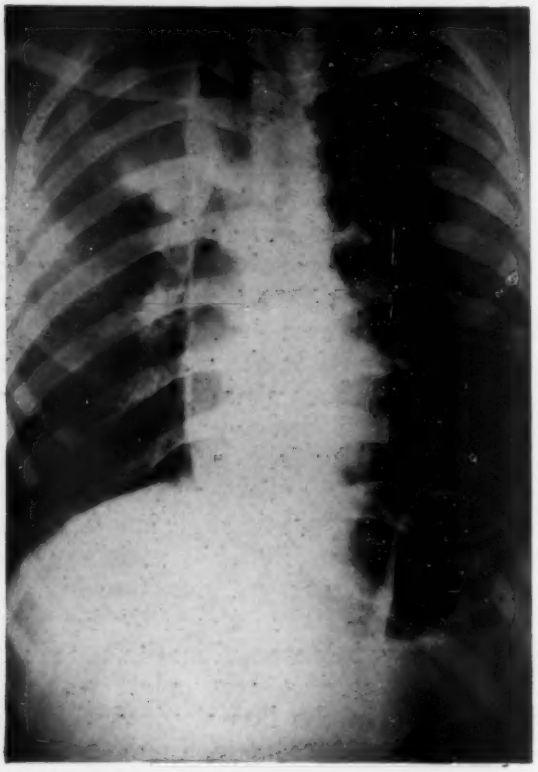


FIG. 6. Case No. 34940. Anteroposterior view showing calcium deposits around lateral aspect of right lung, characteristic of calcified pleura, the end-result of an old effusion in the major pleural sac.



anterior position the fluid makes a shadow usually interpreted as a pneumonia (see Figs. 12 and 13). In the true lateral film the fluid will be seen to have a fusiform shape with convex upper and lower borders, both of which are sharp. This fusiform shadow follows the anatomical location of the interlobar fissure and extends

FIG. 8. E. S. Case No. 39238. Anteroposterior view—patient flexed toward left—showing fluid level in the mediastinum and thickened mesial surface of the right pleura.

from the lung root toward the periphery (see Figs. 19 and 20). In most cases the margins of the fissure are adherent, keeping the fluid within the fissure in all positions of the patient. Rigler,[2] however, describes several patients coming under his observation where he could shift the fluid from the major pleural sac into the interlobar fissures, or vice versa, at will by shift-

FIG. 7. E. S. Case No. 39238. Anteroposterior view—patient erect—showing marked thickening of the mesial surface of the right pleura accompanied by infiltration in the parenchyma of the upper lobe just below the right clavicle.

ing the patient to different positions. I have seen a primary fluid between the lobes rupture into the major pleural sac.

Pneumonia occurring in the lobe near the fissure shows one smooth straight margin while the other is ragged and of the infiltrating type. The area of increased density is not fusiform but is characteristic

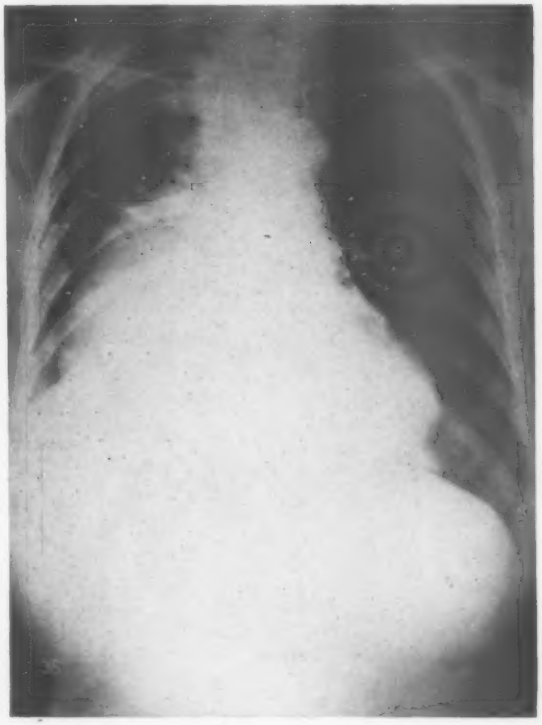


Fig. 9. Case 1. Anteroposterior view—patient erect—showing shadow with convex lateral border extending laterally beyond right heart shadow. Slight thickening of the septum between the upper and middle lobes.

of the involved area (see Figs. 19 to 24).

Fluid in the mediastinum may be in either the posterior or anterior mediastinum. When the fluid is in the posterior mediastinum, it will show as an area of liver density along the spine extending from the diaphragm up to the lung root. It is more easily detected on the right be-

Fig. 10. Case 1. Lateral view of patient in Figure 9 showing encysted fluid projecting forward from posterior chest wall—posterior mediastinum and interlobar fluid between middle and lower lobes anterior.

Fig. 11. Case 1. Lateral view of patient in Figures 9 and 10 after drainage of pus from posterior mediastinum and insertion of rubber tube. The interlobar fluid is still present but was "needled" and found to be nonpurulent.

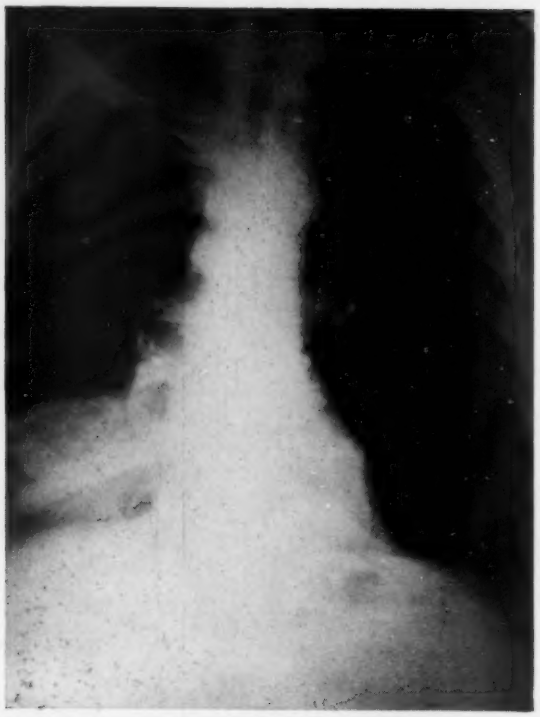


FIG. 12. Case II. Anteroposterior view—patient erect—showing an area of increased density apparently in parenchyma of lower right lung.

cause the density of the heart shadow obscures the left side. However, if the quantity of fluid is great enough, it will show on both sides extending out lateral to the heart shadow. Lateral view will show the area of density posterior.

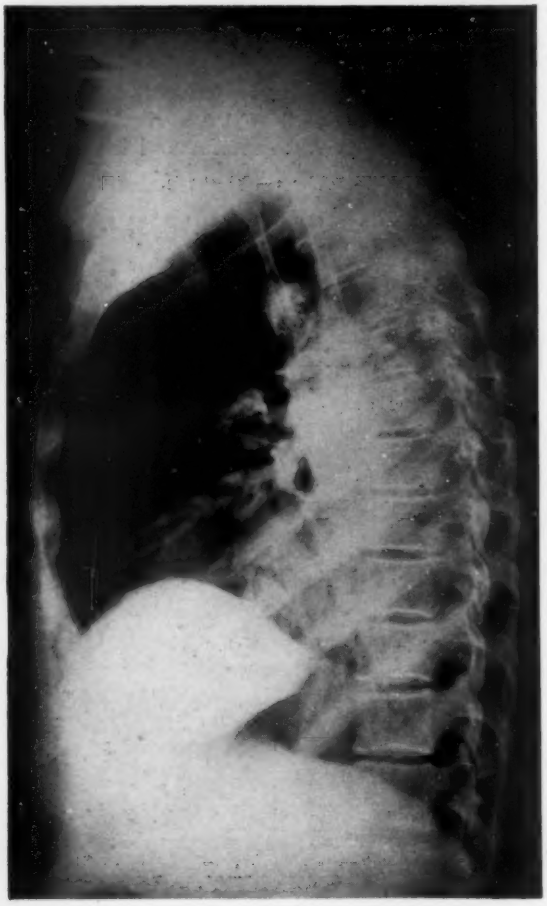


FIG. 13. Case II. Lateral view of same patient proving the density due to fluid between the right middle and lower lobes.

FIG. 14. D.E.F. Case No. 38725. Anteroposterior view—patient erect—showing an area of increased density in lower right lung field.

Fluid in the anterior mediastinum shows as a dense shadow extending from the diaphragm upward, the base at the diaphragm and the apex upward, the shadow showing either to the right of the heart or to the left of the aorta. Lateral films show the density under the sternum.

In some cases the thickened mediastinal surface of the pleura can be distinctly seen (see Figs. 7 and 8).

DIFFERENTIAL DIAGNOSIS

Blumer[3] states that:

In the differential diagnosis between early pneumonia and other acute conditions, x-ray

Fig. 16. Case III. Anteroposterior view—patient erect—showing liver density of right lung field extending to the level of the second rib anterior.

examination of the chest and white blood count are of definite values . . . the method is sometimes of very definite value early in the disease in serving to confirm the presence of a suspected pneumonia, especially when the symptoms are somewhat equivocal and the physical signs are slight.

Fig. 15. D.E.F. Case No. 38725. Lateral view of same patient proving the density due to fluid between the right middle and lower lobes. Note both upper and lower borders are convex and sharp and extend from the lung root forward to the anterior lung margin.

Our experience confirms that of Blumer and we can even go further saying that the present day roentgen examination of the chest makes the diagnosis positive, where, without the roentgen ray no positive diagnosis could be made. Frequently we see patients who have had a respiratory infection manifested by cough, little or no fever, and negative physical findings extending

Fig. 17. Case III. Lateral view of patient in Figure 16 proving the density due to fluid between the right middle and lower lobes through the entire fissure.

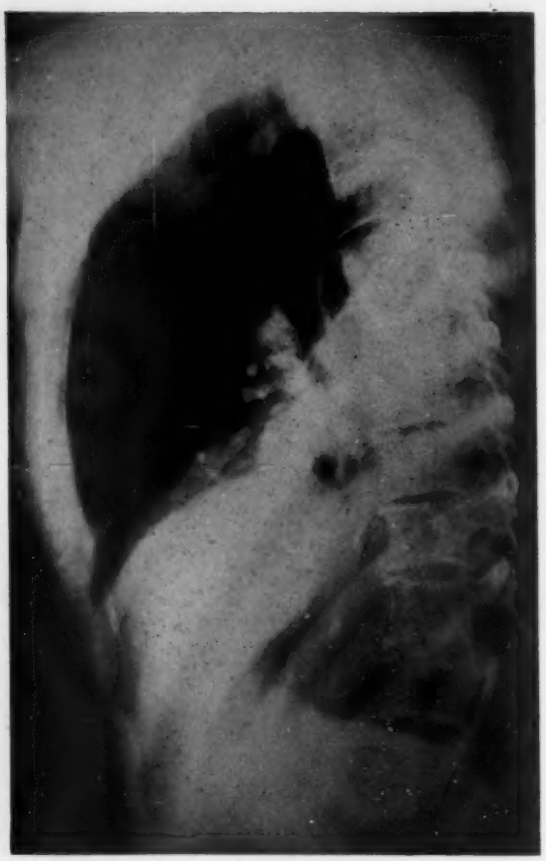


FIG. 18. Case III. Lateral view of patient in Figures 16 and 17 after needle aspiration of fluid from the superior fissure, the fluid in the inferior fissure undisturbed.

over several weeks, in whom roentgen examination shows either a central pneumonic area or interlobar effusion.

Tabulation of the findings of the various pleural diseases in parallel columns will show briefly the differential diagnostic points illustrated by the cases cited in the following paragraphs.

Levitin and Brunn[4] made a study of 100 cases of interlobar fluid seen at the University of California, which showed 98 on the right side while only 2 were on the left side. On the other hand, pneumonias were equally divided between the right and left side. Blumer,[3] in discussing mediastinal pleurisy states that, "x-ray examination is indispensable in diagnosing the condition."

REPORT OF CASES

CASE I (Figs. 9, 10 and 11) (No. 7129 I.H.). Mr. R. Upper respiratory infection five days. Suddenly ill sixth day. Râles and increased breath sounds with flatness over right base posterior near spine. Temperature 101–103.6° F.; White blood count 24,400–45,200. Sputum Type 1 pneumococcus. Roentgen examination shows an area of increased density extending lateral to right heart border, base below, apex above. Lateral view shows convex border forward from posterior chest wall and fusiform area, sharp upper and lower borders between right middle and lower lobes.

Free Fluid		Encysted Fluid	Interlobar Fluid	Central Pneumonia	Lobar Pneumonia
Effusion	Empyema		Resp Inf.	Resp Inf.	Chill
Rub +	Rub −	Rub +	Rub −	Rub −	Rub?
Temp. low	Temp. high	Temp. high	Temp. low	Temp. low	Temp. high
Flat	Flat	Flat	?	Dull?	Dull
B.S. −	B.S. −	B.S. −	?	Râles?	Bronchial
W.B.C. low	W.B.C. high	W.B.C. high	W.B.C. low	W.B.C. low	W.B.C. high
X-ray	X-ray	X-ray	X-ray	X-ray	X-ray
Costophrenic angle obl.	Costophrenic angle obl.	angle clear	angle clear	angle clear	angle clear
Curve of Damoiseau	Curve of Damoiseau	—	—	—	—
Shifting	Shifting	—	—	—	—
		Borders convex	Fusiform density	One sharp, one infiltrating border	Density shape of lobe
			Borders sharp		
			Fissure area 98% right		

Operative findings—200 cc. pus from posterior mediastinum, nonpurulent fluid between right middle and lower lobes.

Case II (Figs. 12 and 13) (No. 7246 I.H.). Mrs. W. Respiratory infection one day. Temperature 100–101° F. Chest negative, except râles right upper anterior. White blood count 41,800; sputum gram-positive diplococci. Roentgen examination shows multiple small areas of increased density in parenchyma, right upper lobe with slight thickening of sep-

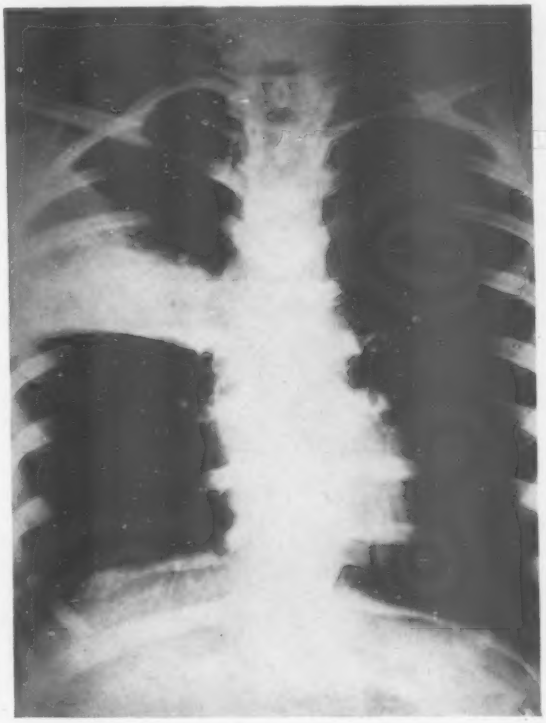


Fig. 19. Case IV. Anterior view—patient erect—showing an area of increased density in the middle of the right lung field. Note sharp inferior border and infiltrating superior border.

tum. Fusiform area increased density in fissure between right middle and lower lobes. Operative findings—interlobar empyema between right middle and lower lobes.

Case III (Figs. 16, 17 and 18) (No. 8460 I.H.), Mrs. J. B. Upper respiratory infection two months, worse past week. Dull right middle and lower lobes. Breath sounds absent

Fig. 20. Case IV. Lateral view of patient in Figure 19.

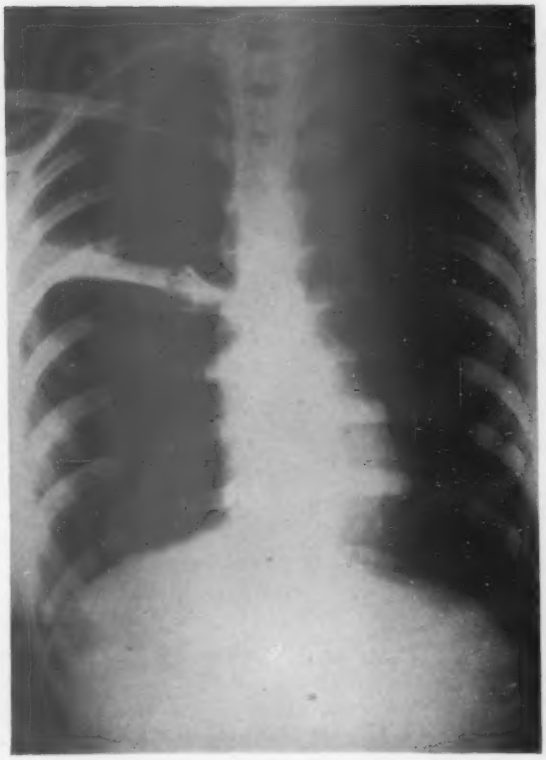
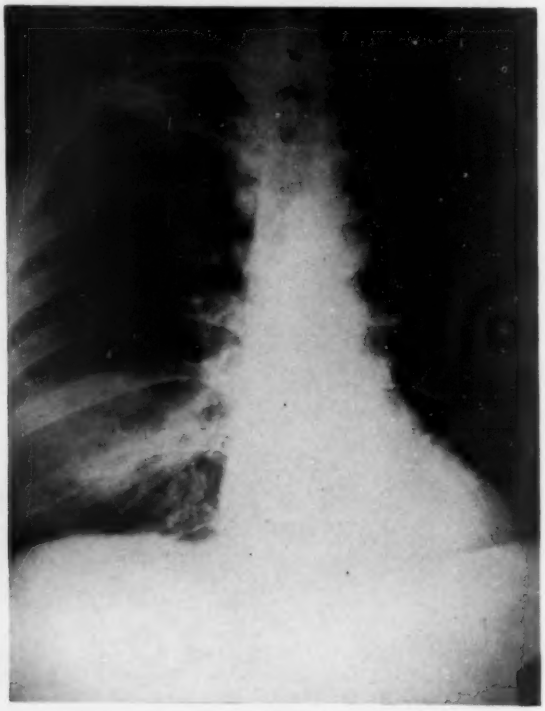


Fig. 21. Case IV. Anteroposterior view of patient in Figures 19 and 20, two weeks later.

FIG. 22. Case IV. Lateral view of same patient two weeks after Figure 20 showing decrease of vertical dimensions of area of increased density but the same sharp inferior border proving the density due to pneumonia along the inferior border of the right upper lobe.



right middle, increased right lower posterior. Temperature 101° F. White blood count 21,600. Sputum, gram-positive diplococci—not typed. Aspiration fluid from superior right fissure not purulent. No white blood cells. Coagulated at once.

CASE IV (Figs. 19, 20, 21 and 22) (No. 8540 I.H.). Miss D. T. Upper respiratory infection four weeks. Chill twenty-four hours ago. Temperature 101° F. Increased fremitus right side.

FIG. 24. Case V. Lateral view of patient in Figure 23. Note sharp upper border, infiltrating lower proving the area of increased density due to pneumonia along the superior margin of the right middle lobe.

Sputum Type VII pneumococci. Roentgenograms show an area of increased density right upper lobe, smooth lower border, infiltrating upper border. Pneumonia lower portion right upper lobe.

CASE V (Figs. 23 and 24) (No. 8494 I.H.). J. W. N. Upper respiratory infection two weeks. Chill forty-eight hours ago. Temperature 102.4°F. Râles; white blood count 14,800–

FIG. 23. Case V. Anteroposterior view—patient erect—showing an area of increased density in the right lower lung field.

19,800. Sputum pneumococci Type III. Roentgenograms show an area of increased density near right lung root, smooth upper border, infiltrating lower border. Pneumonia upper portion right middle lobe (central type).

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THE PARADOXICAL MOVEMENT OF THE DIAPHRAGM AND MEDIASTINAL SHIFT

CINEFLUOROGRAPHIC STUDIES*

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ROENTGENOGRAPHIC and roentgenoscopic examination of the thorax has changed the entire procedure in the treatment of diseases of the chest. Before the roentgen ray was available, diagnosis, even by one well trained in the interpretation of physical signs and symptoms, was difficult. What we know as a "clinical impression" was the beginning and end of the knowledge that could be used as the basis for treatment. All of you have seen patients with far advanced bilateral tuberculosis devoid of physical signs. You have also seen patients with chronic cough, weight loss, night sweats and other symptoms suggestive of tuberculous involvement who proved to have nothing more serious than a chronic sinus infection. The value of routine roentgenography is now too well recognized to require any further consideration.

The roentgenogram provides a study in density of the chest and we can easily identify parenchymal infiltration, lymph node enlargement, thickened pleura, fluid and innumerable other pathologic changes in the architecture of the thoracic viscera. This increased information concerning pathological conditions involving the lungs has permitted the increased use of therapeutic procedures such as thoracoplasty, pneumonolysis, pneumothorax and phrenic crushing in selected cases. In fact, most of the information necessary for proper treatment of chest diseases is obtainable roentgenographically, and more common abnormal motions of the diaphragm, mediastinum and chest wall can often be noted on a brief roentgenoscopic examination.

After pneumothorax, diagnostic or therapeutic, and after surgical procedures involving the chest wall or diaphragm, complicated abnormal motions of the thoracic walls and viscera are frequently encountered. Often times these abnormal motions, bizarre and exciting as they may appear, are of no important pathological significance. In other cases, a careful study of these peculiar movements may disclose hitherto unsuspected lesions and may point out the necessity for a change in therapy. It is with this latter group of cases that we are primarily concerned. The motions of the thoracic walls and viscera are the result of a great many forces working in equilibrium with each other. Factors such as nerve and muscle function, elasticity of the lungs, patency of bronchi, presence or absence of fibrotic change in the pulmonary parenchyma, pressure in the pleural cavity and many more, must all be considered in the analysis of any pulmonary movement. It is obvious when so many forces are at work at the same time that the process of disentangling and evaluating the various components is a slow and tedious one. It is certain that roentgenoscopy should not be used in this study. It subjects the patient and the examiner to too great an amount of radiation. It is tiring and often too hurried to be effective. It is for this reason that we have applied the method of cinefluorography to this work. It permits protracted study of the motion without danger to the patient or examiner.

It is not our intention to present an exhaustive analysis of thoracic dynamics. Such a labor would require years of work and would, in most cases, yield information of only academic interest. It is our wish, however, to attempt an exposition of the merits of this new method of investigation

* Read at the Thirty-ninth Annual Meeting, American Roentgen Ray Society, Atlantic City, N. J., Sept. 20–23, 1938.

and to demonstrate in a few cases how clinically useful information has been obtained.

We shall first demonstrate the normal respiratory movements of the thoracic viscera, the descent of the diaphragm and the normal expansion of the chest walls on inspiration. The act of inspiration is accomplished by increasing the volume of the thoracic cavity. In some cases this is done almost entirely by diaphragmatic activity. In most individuals, however, inspiration is both diaphragmatic and costal. The mechanism of costal respiration is dependent upon the downward inclination of the ribs as they pass from behind forward. The elevation of the sternum which is attached to the anterior portion of the ribs brings about the increase in the volume of the thorax on inspiration. Since the lung, in normal subjects, is freely suspended in the thoracic cage and attached only at the hilum there is a potential space which surrounds the lung on all sides. This potential space (that is, the pleural cavity) contains nothing but a few cubic centimeters of fluid under normal conditions. The physical chemical characteristics of the cells and capillaries of the normal pleura keep the pleural space empty and prevent the accumulation of either gaseous or fluid matter.

The pulmonary parenchyma contains a large amount of elastic connective tissue fibers which tends to cause almost complete collapse of the lung unless prevented by some outside force. This collapse of the lung, however, is prevented by a difference in the gaseous pressure in the alveoli of the lung and in the pleural space (the so-called negative pressure of the pleural cavity). This negative (to atmospheric) pressure in the pleural space is balanced by the elastic recoil of the lung. To follow this point a little further, we note that the elastic recoil of the lung is different in the changing phases of respiration. The greater the distention of the lung, the greater the force necessary to keep the visceral and parietal pleura in contact. Thus we see the reason for the changes in the intrapleural pressure in the different phases of respiration. This conception of the mechanics of normal respiration is necessary for the understanding of some of the pathological conditions which we will now describe.

A condition frequently seen following phrenic crushing and easily recognized on brief roentgenoscopic examination is paradoxical motion of the diaphragm.

If the chest is otherwise normal, the entire change in the process of respiration which occurs can be ascribed to the interruption of the phrenic nerve and the resultant complete paralysis of the diaphragm. With paralysis of a leaf of the diaphragm there is a complete loss of any intrinsic force. Any movement of the diaphragm must be the result of extrinsic pressure. Consequently, the expansion of the chest wall against the elasticity of the lung on inspiration increases the negative intrapleural pressure. The paralyzed diaphragm is sucked upward by the increase in this negative intrapleural pressure and the motion is aided by the concomitant increase in the intra-abdominal pressure caused by the descent of the opposite normal diaphragm. On expiration the reverse occurs. The positive abdominal pressure decreases and the negative intrapleural pressure decreases at the same time, causing the paralyzed diaphragm to be carried downward. With this paradoxical diaphragmatic movement there may be a sway in the mediastinum. This occurs only when the mediastinum is movable and is not likely to be seen when the mediastinum has been fixed by adhesions. The mechanism depends upon the difference in the pleural pressures on the two sides. The greater the distention of the lung, the greater the elastic recoil of the lung and consequently the higher the negative intrapleural pressure. After the diaphragm has been paralyzed the affected side cannot descend as much as the normal side and cannot expand the lung to as great a degree. This means that the negative intrapleural pressure is higher on the normal

side of the chest and there is a compensatory shift of the mediastinum toward the normal side on inspiration and a return to the original position in expiration. This swaying motion of the mediastinum is usually slight but it can be easily demonstrated in many cases.

In cases of therapeutic pneumothorax many of the same factors are involved. When air is introduced into the thoracic cavity and when the visceral and parietal pleura are not bound together by adhesions, partial collapse of the lung occurs. This causes a decrease in the elastic recoil of the lung and a decrease in the negative intrapleural pressure. A resultant shift of the mediastinum occurs from the affected toward the normal side. This may be very slight or may displace the mediastinum far into the normal side of the chest. A point of equilibrium, however, is reached in which the resistance of the mediastinum offsets the differences between the pleural pressure on the two sides.

We have made observations on a large number of pneumothorax cases and noted that in practically all instances there is a mediastinal motion on respiration. The cardiac and mediastinal shadows move toward the pneumothorax side on inspiration and return toward the normal side on expiration. This we have called the normal mediastinal motion in the presence of a pneumothorax. The explanation for this movement is not as simple as it would at once appear. It is apparently due to the fact that the rise in the negative pressure in a pneumothorax is greater than the rise in the negative pressure on the normal side during inspiration. In other words, a decrease in the absolute pressure on the pneumothorax side is the result of Boyle's law covering the volume and pressure of gases in a closed system, while on the normal side the rise of the negative pressure or the decrease in the absolute pressure on inspiration is a function of the elastic recoil of the lung alone. Depending upon the degree of pneumothorax, the character of the pleura and the contractility of the elastic fibers of the partially collapsed lung the effect of Boyle's law on the pneumothorax side is somewhat modified. The actual observation, however, is constant—that the mediastinum moves toward the pneumothorax side on inspiration and therefore the negative pleural pressure on the normal side must of necessity increase to a less degree on inspiration than the negative pressure on the pneumothorax side.

When a pneumothorax is present on one side the amount of expansibility of the partially collapsed lung determines, to a large extent, the amount of mediastinal sway. When the lung is perfectly normal and expansile, only a small amount of mediastinal shift is usually noted. When, however, the partially collapsed lung tissue has lost its ability to expand, the mediastinal sway is greater in degree. The lung may be prevented from expanding by a number of causes; infiltration and fibrotic change in the lung parenchyma, thickening of the visceral pleura and obstruction of a large bronchus all act in the same manner. As was stated above, negative pressure in a pneumothorax cavity increases to a greater degree on inspiration when the lung is non-expansile. For this reason, an obstructed bronchus in a partially collapsed lung will increase the degree of mediastinal sway toward the affected side on inspiration and away from the affected side on expiration. The mechanism of this is exactly the same no matter whether the lung is prevented from expanding by an obstructed bronchus, by visceral pleural thickening or by parenchymal fibrosis.

We noted, in the discussion of simple phrenic paralysis, that the mediastinum tended to move toward the normal lung in inspiration. As a rule, however, the amount of motion of the mediastinum was less in degree than that seen in connection with a pneumothorax. When both a pneumothorax and a phrenic paralysis are present on the same side of the thorax, as is frequently seen in patients under therapy for pulmonary tuberculosis, the resultant mo-

tion of the mediastinum on inspiration is toward the pneumothorax side, although this tendency is opposed by the pleural pressure relationships which have been caused by the paralysis of the diaphragm.

The analysis of the motions of the mediastinum is frequently complicated by the presence of pleural adhesions. Depending upon the density and the location of these adhesive bands a great variety of secondary mediastinal motions may occur. It is obvious that an adhesive band connecting the lateral chest wall and the mediastinum will in most instances result in a deviation of the mediastinum toward the side on which the adhesions lie, irrespective of other forces, as the adhesion acts as a firm connection between the muscularly powerful chest wall and the relatively easily displaced mediastinum. Thinner and more delicate adhesions may show less pronounced action on the mediastinum and may demonstrate only a moderate degree of elongation during the act of inspiration.

Frequently adhesive bands are present between the apex of a partially collapsed lung and the upper portion of the chest. In connection with this another adhesive band may be present connecting the lower part of the partially collapsed lung and the diaphragm. With such a setup as herein described, the lung has a three-point suspension, being connected to the apex of the chest, the diaphragm and the mediastinum. On inspiration, the diaphragm descends and causes traction on the two lateral points of suspension. This again may cause a deviation of the mediastinum toward the affected side. The number of possible methods by which adhesions may influence the movements of the thoracic viscera is very great and it is impossible to make any generalities.

An interesting group of cases was first recognized by Kienböck in 1898 and the respiratory movements described at that time are now known as Kienböck's phenomenon. This condition involves the elevation of a fluid level in hydropneumothorax cavity at inspiration and a descent of the fluid level on expiration. In other words, a paradoxical motion of a fluid level in a pneumothorax cavity. At that time it was believed that the weight of the fluid in the pneumothorax cavity had caused a reversal of the diaphragm so that the convexity was downward instead of upward. It was believed that the contraction of the diaphragm caused flattening of this half of the diaphragm and forced the fluid level upward on inspiration.

In 1935 Stivelman* reviewed this subject and analyzed a large group of his own cases. He demonstrated that Kienböck's phenomenon could be produced in three ways and showed that it occurred in cases having a high positive pressure pneumothorax, in cases having a high negatve pressure pneumothorax and in cases with a paralyzed diaphragm. The fundamental conception in the understanding of the first two methods of production of Kienböck's phenomenon involves the relative strength of the muscles of the diaphragm and of the thoracic wall. Where differential pressures are so arranged as to cause direct opposition of the chest wall and the diaphragm, the more powerful muscles of the thoracic wall may completely reverse the normal action of the diaphragm. In high positive pressure pneumothorax, the diaphragm is depressed on expiration by the force of the air in the pleural cavity. As the thoracic wall expands on inspiration part of the pressure on the diaphragm is released and an upward motion occurs. When a fluid level is present in such a pneumothorax cavity it is noted to rise on inspiration and to fall on expiration. When a high negative pressure pneumothorax is present, the expansion of the chest wall on inspiration further increases the negativity of the pneumothorax so that the relatively weak diaphragm is aspirated into the chest. This, in a similar manner, produces a rise of the fluid level in the base of the pneumothorax on inspiration and a descent on expiration. The third method by which Kienböck's

* Stivelman, B. P. Paradoxical pleural pressures; their relation to Kienboeck phenomenon. *Am. J. M. Sc.*, 1935, *190*, 256–263.

phenomenon may be produced is similar to the paradoxical motion seen in a paralyzed diaphragm without the presence of fluid previously described. This type of Kienböck's phenomenon is only a variation of ordinary paradoxical diaphragmatic motion and may occur in any case which has a hydropneumothorax and a paralyzed diaphragm on the same side.

CONCLUSION

(1) The study of abnormal diaphragmatic and mediastinal movements may yield information of value in the understanding and management of pulmonary disease.

(2) Cinefluorography permits safer and more effective study of such phenomena.

(3) An analysis of the motions which may be studied is briefly given.

DISCUSSION

Dr. John T. Farrell, Jr., Philadelphia. Dr. Stewart's demonstration opens to me an entirely new field. I can readily appreciate what he has said about the importance of the procedure.

What he has said about the impossibility of adequately studying the patient fluoroscopically, because of the danger to the patient and to the examiner, should be emphasized. We might add that he is opening a new field of study; one might call it pleuropulmonary dynamics. As we now study the respiratory function with animals, the situation is artificial. However, with cinefluorographic studies, which can be repeated and looked at as often as one wishes, many of the mysteries of the dynamics of negative pleural pressure, positive pulmonary pressure, and the effect of the elastic and interstitial tissues of the lung will be opened up to us.

The method, of course, supplements the procedure which Dr. Manges so often advocated in the study of foreign bodies; namely, the making of roentgenograms at deep expiration and deep inspiration. Though it adds much more than the films themselves do, in those cases where the pulmonary and pleural shadows are complicated by changes due to motion, repeated study will enable us to determine the true state of affairs more readily.

There are other things which must have struck all of you who were looking at the film, as I was, for the first time. It gave me an altogether different conception of the chest, for I am accustomed to looking at various portions of the chest fluoroscopically, through a limited area. With this procedure, one gets an entirely different perspective, an entirely different notion of the mechanism of the respiratory organs.

I would like to congratulate Dr. Stewart and Dr. Ghiselin on their very informative work.

Dr. Merrill C. Sosman, Boston. I am glad to have the opportunity of discussing this paper because it is such a beautiful demonstration. It could be so remarkably useful in teaching, not only medical students but also thoracic surgeons and those who are using pneumothorax in the tuberculosis hospitals and sanatoriums.

The one thing that struck me as particularly interesting was the demonstration of the increased amplitude of pulsation of the heart on the side where the pneumothorax is present.

Those of you who do a good deal of fluoroscopy have noticed that peculiar, very striking amplitude of the heartbeat on the side of the pneumothorax. Sometimes there is a very small pneumothorax and the only evidence you may get in the fluoroscope is this increased pulsation on the side where the pneumothorax is present. The other part of this demonstration is something that none of us has been able to do, and that is to actually record the fluoroscopic examination on the movie film. I think the entire Society owes Dr. Stewart and Dr. Ghiselin a vote of thanks for this very excellent presentation.

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CALCIFICATIONS IN THE SPLENIC REGION

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DURING the routine examination of abdominal roentgenograms calcifications in the region of the spleen are encountered rather frequently. These concretions are often the occasion for speculation as to their nature and significance. It was therefore thought advisable to investigate the calcifications occurring in this region in order to establish the possible causes and indicate some points in the differential diagnosis of these calcium deposits.

Roentgenologically, the splenic area calcifications appear most reasonably grouped as follows:

I. Splenic
  A. Small, usually multiple shadows
    1. Phleboliths
    2. Tuberculosis
    3. Parasitic (Pentastoma)
    4. Calcifications of undetermined origin
  B. Large, usually single shadows
    1. Perisplenitis
    2. Infarcts
    3. Hematomata
    4. Abscesses
    5. Cysts
      a. Echinococcus
      b. Non-parasitic
  C. Miscellaneous
    1. General increased density of spleen
    2. Iron and calcium incrusted spleen
II. Splenic vessels
  A. Artery
  B. Vein
III. Extrasplenic
  A. Concretions in other organs
    1. Adrenal
    2. Pancreas
    3. Retroperitoneal tissues
  B. Miscellaneous
    Costal cartilages, nodules in the lung and pleura, calcified trichina and cysticercus cysts, calcified glands, renal artery, concretions in the upper gastrointestinal tract, lesions in the skin.

PHLEBOLITHS

Splenic phleboliths are found not infrequently at the autopsy table.[39,54,57,61] Wydler,[103] in 1911, published the results of an extensive investigation into their nature. He demonstrated the stones in ectatic vessels. They appear to be due to small thrombi which undergo hyalinization and calcification with or without preliminary organization. Their structure consists of a central, calcified core usually surrounded by peripheral lamellae. Ossification may occur later. The calculi finally become attached to the intima of the veins with resulting intimal calcifications. Autopsy findings in 7 cases reported by Bársony and Schütz[8] and in 3 patients recorded by Berman[10] revealed splenic phleboliths. All of the patients were more than fifty years of age, and the majority were past sixty years.

On roentgenographic examination phleboliths appear typically as match-head to pea-sized, round, dense concretions of regular outline. Their number varies greatly, from few to perhaps more than a hundred. Each individual shadow may have a homogeneous or laminated appearance with a denser core. The latter is quite characteristic of this type of calcification. Atypical variations are frequent, however. The concretions may be quite large, as in Jablon's proved case of marble-sized shadows in ectatic, hilar branches of the splenic vein.[51] They may be of heterogeneous density with irregular outline and shape.

While the typical appearance of the calcifications in patients over fifty years of age and without any evidence of tuberculosis is highly suggestive, nevertheless it is often impossible to differentiate phleboliths from calcified tuberculous foci or *Pentastomum* larvae. The younger the patient the greater the improbability of phlebolith formation. Rudisill,[84] Polgár and Szemzö,[80] and Koppenstein,[62] have published cases whose roentgenograms were believed by the authors to be characteristic of splenic stones. However, none of the cases were substantiated by morphological study, and the accuracy of their interpretations has been questioned.[85,87] Many of these patients were under fifty and some below thirty years of age.

Three cases with phleboliths in the spleen were found among the autopsy material at the Mount Sinai Hospital. The structure of the concretions was typical in each case. All of the patients were over fifty years of age. An abdominal roentgenogram of one of these patients demonstrated a moderate number of match-head-sized, round, dense shadows in the splenic region.

TUBERCULOSIS

The incidence of tuberculosis of the spleen has varied with different investigators from 0.6 per cent[3] to 17.1 per cent.[60] Reinhold[102] reported that two-thirds of children dying of tuberculosis showed splenic involvement. Of the adults only 19.1 per cent had splenic infection.

Infection of the spleen with the tubercle bacillus occurs almost exclusively via the blood stream, resulting in the formation of tubercles. A perhaps slightly greater number of organisms tend to settle in the hilar region.[92] The ensuing course depends entirely upon the severity of the infection and the general and local resistance of the host. The tubercles usually develop in lymph nodules and adjacent regions, i.e. in the malpighian corpuscles, or in the wall of a trabecular artery.[39] Regardless of size, the progression of the developed tubercles follows three major courses: (1) fibrosis, hyalinization and final calcification and ossification; (2) growth and caseation to be followed by fibrosis, hyalinization and calcification. Rarely the caseation results in ulceration; (3) mixed forms of the above two. It is therefore apparent that calcification is the final stage—though not necessarily reached by each tubercle—in the life cycle of each tuberculous nodule. Further, two tubercles deposited simultaneously, or even different parts of the same tubercle may progress differently or be in different stages of their course. Thus, calcification and residual activity, perhaps with caseation, may coexist even in the same tubercle. The latter, however, is infrequent.[57] The greater the number and the larger the size of the tubercles the greater is the degree of splenic enlargement.

Calcifications have been observed in the following types of splenic tuberculosis:

1. Patients with more protracted forms of tuberculous bacillemia demonstrate deposits of varying numbers of bacteria, and often at repeated intervals. The most varied types and sizes of tubercles are found in these cases. The largest spleens are also found during the active stages of growth and proliferation of the various sized tubercles in this type of the disease.[43,58,102] As the process grows more chronic and fibrotic changes become prominent, the spleens are found to be smaller. Since calcification represents a late stage in the development it is only exceptionally found in cases with huge splenomegaly. In such cases the calcifications tend to be large in size—since they are deposited in large caseous tubercles quite frequently. The primary source of the bacillemia is usually apparent. Occasionally it may not be discovered.[39,43,81,91]

2. Patients in whom there is only a small spread from the focus to the spleen present a mild form of infection. Comparatively few bacilli are deposited and the spleen is well able to encapsulate and prevent continued growth of the organisms. There results a varying number of small, encapsulated and fibrotic tubercles. Hyalinization and calcification is quite frequent, and the spleen practically never enlarges. In none of Klotz's[60] 69 cases of mild tuberculous splenitis was there any splenomegaly pathologically. In 40 of the spleens all signs of activity had entirely disappeared. Very many of these showed numerous small calcified tubercles. Hektoen[37] and others[36,57] have found frequent calcification of small tubercles often without any evidence of active disease in the spleen. It is therefore in these normal sized spleens with inactive tuberculosis that calcified tubercles are most often observed. However, the tubercles and calcifications are quite small—usually no larger than pea size.

The calcifications associated with active tuberculous splenitis may be distinguished roentgenologically from those of the quiescent, unimportant types. Cases of active splenitis with calcifications have been recorded very infrequently. They are characterized by large spleens, nearly always with a coarsely nodular surface,[58] in which there are found varying numbers of concretions from a few millimeters to about 3 cm. in size.[24] The smaller ones tend to be round, while the larger opacities are often irregular in shape and outline. Other evidence of chronic hematogenous tuberculosis is often found coexistent. Shands[91] has reported 3 cases and Bunch[18] 1 example of nodular splenomegaly with large calcified tubercles due to active tuberculous splenitis. All cases presented sufficient symptoms to warrant splenectomy. Following operation all showed marked improvement. The spleens showed active tuberculous lesions at various stages of progression in addition to the calcified tubercles. Caseation was also observed. Thus, a roentgenogram of a pneumoperitoneum demonstrating an irregular, coarsely nodular, enlarged spleen containing calcifications and surrounded by adhesions (due to the coexisting peritonitis) indicates the presence of tuberculous splenitis.[72]

Small calcifications in completely arrested and obsolescent cases of tubercle bacillus infections of the spleen are seen quite frequently.[17,20,48,92,96] Many of these cases show evidence of tuberculosis elsewhere. Hellgren[38] was able to observe the development of small calcifications in a normal sized spleen of a child aged seven. The patient had recovered from a typical primary infection type of pulmonary tuberculosis discovered four years previously. The characteristic roentgenogram presents a small or normal sized spleen with a greatly varying number of round, moderately regular concretions from a few millimeters to 0.5 cm. in size. Evidence of tuberculosis elsewhere may or may not be present. Differentiation from phleboliths is very often impossible. The younger the patient, the more likely are the concretions to be due to calcified tubercles. Fortunately, in this instance the differentiation is only of academic interest since both conditions are clinically unimportant.

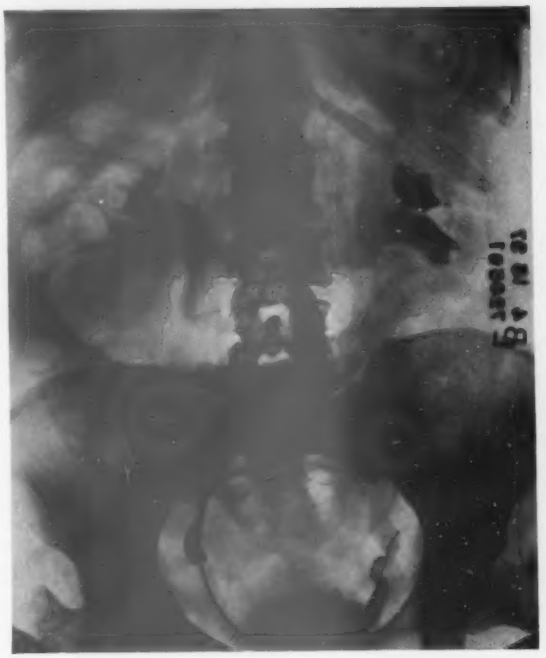

Fig. 1. Probably active tuberculous splenitis with calcifications. Bilateral tuberculosis of the genitourinary tract.

Six cases of healed tuberculous splenitis with calcified tubercles were reviewed. In each case the spleen was of normal size and the calcifications were a few millimeters in diameter. Four of the 6 patients were under fifty years of age. The other two were fifty and fifty-two years old. Thus, while the youth of the patient favors the diagnosis of calcified tubercles, old age is not as indicative of phleboliths since the presence of healed tuberculous splenitis does not influence the life span of the patient.

Among the cases of active splenitis was that of a patient aged seventy, who entered in diabetic coma. At autopsy the spleen weighed 310 grams and contained a number of small tubercles. Some were active and showed necrosis and caseation, while others were well calcified. A number of calcified tubercles contained caseous centers.

Figure 1 illustrates a case with proved hematogenous tuberculosis. The size of the spleen and the intrasplenic calcifications indicates that the tuberculous infection is most probably in the active stage.

PARASITIC INFESTATIONS

Calcified larvae of *Pentastomum taenoides* have been noted in the spleen by various observers. The *Pentastoma* (*Linguatula rhinaria*) lives in the nose of the dog. Its larvae are ingested by the human and penetrate the intestinal wall, entering the portal circulation. They have been found in the lung, kidney, liver and spleen. At the site of their deposition the organisms invariably die, are surrounded by a fibrous capsule and become calcified[54]. The infestation is of no clinical significance.

Roentgenographically, the calcifications tend to be round and vary from a few millimeters to 0.5 cm. in diameter. Klemperer[57] has observed them to be somewhat larger and clover leaf in shape. They are usually few in number. Similar concretions may be found in the liver and kidneys. In the spleen the differential diagnosis from phleboliths and small calcified tubercles may be entirely impossible.[39,85] Saupe[87] has reported one case of proven *Pentastoma* infestation of the spleen. His roentgenogram shows a moderate number of small, intrasplenic calcifications.

CALCIFICATIONS OF UNDETERMINED ORIGIN

Occasionally there may be found small, calcified intrasplenic nodules whose origin is entirely uncertain. No evidence of their cause or associated abnormalities could be discovered.[39] In none of the cases reviewed were the nodules greater than 1 cm. in diameter.

The virtual impossibility of roentgenographically distinguishing such calcifications from similar appearing concretions due to phleboliths, *Pentastoma* or small calcified tubercles confined to the spleen is apparent. Fortunately, the number of instances of inability to determine the original pathological processes is comparatively few. Koch bacillus infections are often accompanied by evidence of tuberculosis elsewhere. Old age would favor the presence of venous calculi. A number of case reports illustrating multiple intrasplenic calcifications have been published.[75,80,99] Necropsies were not performed and the morphological nature of these concretions could not be ascertained. As a result, the authors' opinions as to the identity of the calcified lesions could not be corroborated, and in many cases are open to question.

Autopsy material at the Mount Sinai Hospital includes two spleens containing calcified nodules of undetermined origin. One was an acute infectious splenomegaly accompanying uremia. The second was a case with slight splenic enlargement associated with cardiac failure. The nodules varied in diameter from 1 mm. to 0.7 cm.

PERISPLENITIS

Calcified perisplenitis may be caused by various organisms or arise without infection. Pyogenic and non-pyogenic bacteria, *B. tuberculosis* and echinococcus larvae have been found as etiologic agents. Kaufmann and Reimann[54] have classified the modes of origin as follows:

1. From without—by spread from
   a. stomach
   b. colon
   c. left kidney
   d. pleura
2. From within
   a. abscesses
   b. infarcts
   c. chronic hyperplastic and indurative splenitis
   d. echinococcus disease

Pathologically, the process is characterized by a stage of acute inflammation of the capsule which progresses into a chronic inflammatory state accompanied by marked fibrosis. The thick, fibrotic covering may then hyalinize and calcify. The calcium is usually deposited in large plaques surrounding the spleen. Small calcifications deposited in a thick, fibrous capsule have also been noted.[39]

The roentgen appearance of the characteristic case is diagnostic. A large calcification of irregular shape and outline but of uniform density is seen to lie directly over the shadow of the spleen. Occasionally the periphery may appear somewhat more radiopaque due to the incident rays striking this portion of the calcification more tangentially. However, there are no irregular areas of translucency in the shadow. Rarely, more than one calcific plaque may be present, each of characteristic appearance. Since diaphragmatic adhesions are usual in these cases, the calcifications are often observed to move with respiration.

Pallasse, Santy and Chanaleilles[79] decribe a case of painful perisplenitis with plaque-like calcification which was cured only by splenectomy. Stott and Cotton-Cornwall[95] reported a case of calcified tuberculous pleurisy in which the infection spread below the diaphragm and caused a perisplenitis accompanied by sheet-like depositions of calcium on the splenic capsule. The spleen beneath the capsule was not involved. The roentgenological appearance of the condition was characteristic. There was, in addition, a bilateral, fibrocaseous pulmonary tuberculosis.

Three specimens of calcified perisplenitis have been observed. Typical plaques varying in size from 2×1 cm. to 12×15 cm. were present. In one case there were multiple, moderately large plaques. The spleens were of normal size or slightly enlarged.

INFARCTS

Calcium depositions in splenic infarctions are noted only infrequently.[5,12,36] The pathological changes consist of fibrotic organization, hyalinization and calcification of the infarcted areas. Henke and Lubarsch[39] described ossification in one case.

Kadrnka and Babaiantz[53] published roentgenograms of 3 cases, one of which was proved by autopsy. Massive calcified infarcts in the splenic region may be single or double, and are usually triangular or oval in shape. When they are triangular the apex is at the hilum and the base at the periphery. The calcification may be in general homogeneous, porous or cottony. Its contour is usually regular, but may be irregular due to partial absorption. While the large calcified infarct may be differentiated from parasitic and non-parasitic cysts by its shape, location, outline and structure the small calcified infarctions are often indistinguishable from phleboliths, calcified *Pentastoma*, tubercles, etc.

Figure 3, *3* shows the typical, oval, porous calcification with a regular outline. It extends into the spleen from the hilar region. Necropsy of this case revealed a small spleen (100 grams) surrounded by adhesions, and nodular in outline due to the presence of many old, subcapsular organized infarcts. Only one of these old infarctions contained calcium, and this lesion had progressed in sections to complete ossification.

HEMATOMATA AND ABSCESSES

Calcifications in hematomata and abscesses in the majority of instances have been accorded mere mention in the standard pathology texts.[2,5,25,37,39,54] Most authors agree that the calcium is deposited in only a small number of these cases. The deposition in healing abscesses frequently occurs in the form of small masses. Sternberg[94] described a calcified hematoma measuring 3×5 cm. Published illustrations of the roentgen appearance of these conditions have not been found.

ECHINOCOCCUS CYSTS

In a series of 2,117 cases of hydatid disease[76] the spleen was found involved in 68. The condition is especially rare in North America.[74] The cysts tend to be round, vary greatly in size and may extend in various directions, becoming intrasplenic, exteriorized or juxtasplenic in position.[26] Calcification of the wall occurs only in a minority of cases, being unmentioned in the many cases reported by Dieulafoy,[26] Mills,[74] Jones,[52] and Martin.[71] These authors included comprehensive reviews of the literature. Litten,[68] on the other hand,

believed that the cysts were always unilocular and were prone to undergo calcification. The latter is not borne out by a review of the cases reported.

The walls of the cysts become fibrotic and gradually increase in thickness. They may later attain the consistency of an atheromatous plaque in the aorta or of the rings of the trachea.[70] Finally, sheet-like depositions of calcium may occur in the greatly thickened walls. The calcareous plaques vary in number and density. Moynihan[76] believes that calcification occurs late in the disease, and most frequently in the smaller cysts only. Its occurrence, he feels, is a manifestation of the latency and inactivity of disease. Calcification undoubtedly occurs in the borders of the daughter cysts as well as in the main cyst wall.

The calcifications are usually diagnostic. There is most often a splenomegaly. In the enlarged spleen is seen, characteristically, a large rounded ring of calcification. The circle may consist of a single or two closely parallel rings of calcification. The cyst wall may vary from a few millimeters to 1 cm. in thickness. There is great variation in the completeness of the calcified contour. Most frequently rather large sections of the circumference are uncalcified and therefore invisible. The calcification of the ring may be represented only by a small arc, may be entirely lacking, or, very rarely, may occupy the entire circle. Within the calcified circumference are seen a varying number of ill-defined and irregular concretions. Very infrequently these may be absent. It is typical of the condition that the density of the various calcifications never tends to be great. The roentgenological appearances, while they may show considerable variation, are more or less characteristic, no matter what their location.[28,56] Differentiation from the non-parasitic, calcified, splenic cysts (see below) is comparatively simple. Typical roentgenograms of proved cases have been shown by Holl,[46] Druckmann,[28] Boyd,[16] and others.[19,27]

NON-PARASITIC CYSTS

The presence of calcification in the walls of a non-parasitic cyst of the spleen is extremely rare. Only 6 such cases have been described: 4 appearing in Fowler's[30,31] comprehensive review of the literature, and additional reports by Földes[29] and Gatersleben.[33] The exact nature of the calcified cysts has not been definitely determined. Among the causes hypothesized have been splenic trauma[93] and lymphangiomata which become cystic.[33] One case reported by Fowler appeared to be post-traumatic. In the remaining cases there were no indications of the etiology of the condition.

The cysts vary greatly in size. They are usually fairly large, and may hold as much as 3 liters of fluid. The wall is composed of fibrous tissue in which there is a heavy deposit of calcium salts, usually throughout the entire circumference. The deposition is greater and more uniform than in the parasitic cysts.

Roentgenograms of only two cases have been published.[29,33] Both cysts were large, one measuring 8×6 cm. and the other 14×10×6 cm. On the roentgenograms very dense, complete rings of calcification varying up to about 3 mm. in thickness were seen in the splenic region. There were no breaks in the calcification of the circumference. Concretions were absent from the centers of the cysts. The roentgenographic appearance may be simulated only by calcium incrusted aneurysms of moderately large size which occur rarely in the intrasplenic branches of the splenic artery (see below). In such cases it may be impossible to differentiate the conditions.

Figure 2 illustrates the typical roentgen picture of a calcified, non-parasitic cyst of the spleen. At autopsy a small, soft spleen weighing 90 grams was found. In its upper pole was a cyst measuring 2 cm. in diameter. The cyst wall had no epithelial lining and was composed of fibrous tissue completely incrusted with calcium salts. The splenic vessels were normal. There

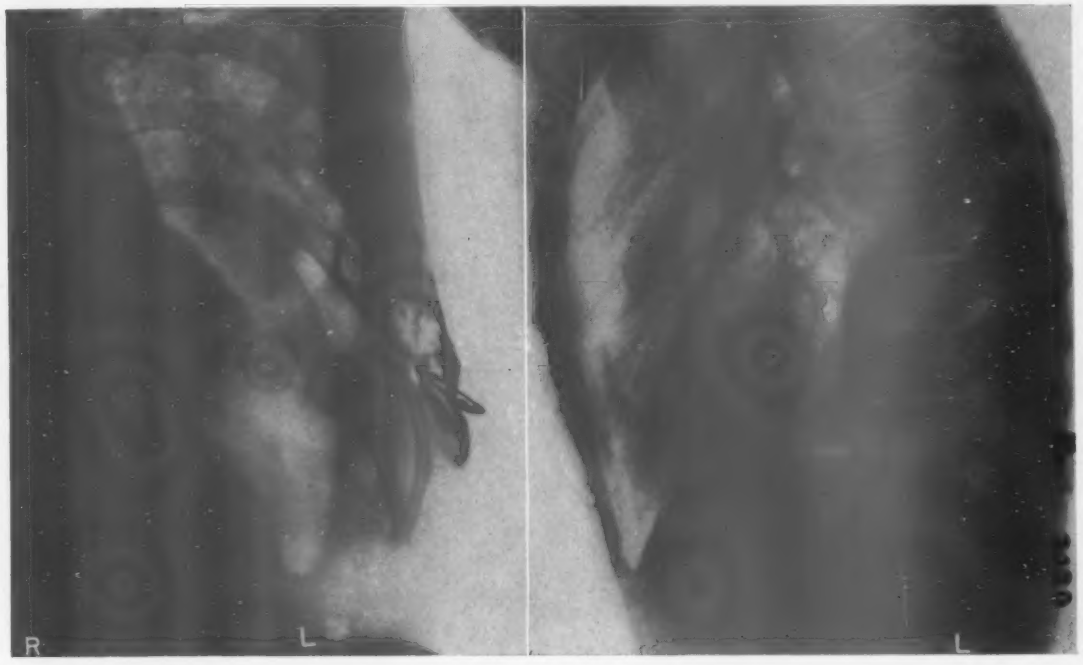

Fig. 2. Calcifications in a non-parasitic cyst of the spleen.

was no evidence of parasitic infestation.

Dermoid cysts of the spleen have been reported twice in the literature.[27,64] Calcifications were absent.

GENERAL INCREASED DENSITY OF THE SPLEEN

The normal spleen usually appears considerably less dense than the liver on the abdominal roentgenogram. It frequently may not be delineated at all on the routine film. Occasionally, the shadow of the spleen, although containing no calcifications, is markedly radiopaque, much more so than the liver. Such a roentgen picture may be seen in cases of marked congestion due to splenic vein thrombosis. Figures 4 and 3, *1* illustrate the great density of the spleen in a case of portal and splenic vein thrombosis complicating an echinococcus cyst of the liver. At autopsy the spleen was found to be severely congested and to contain old and recent infarcts. There were no calcifications, and only a minimal amount of free iron-containing pigment was present. The portal and splenic veins were thrombosed.

IRON AND CALCIUM INCRUSTED SPLEEN

Small depositions and incrustations of iron and calcium in the spleen have often been noted.[39,40,73] Pathologically, these cases show marked fibrosis of the spleen, often an associated hypertrophy and hyperplasia of the corpuscles, thickening and hyalinization of the small splenic arteries in whose walls and about which are found the depositions.[22] The condition is considered to result from the deposition of calcium and blood pigment in areas of organized perivascular hemorrhages.[57,59] Although the condition is of little clinical significance, some observers have suggested that the calcifications may be visualized on an abdominal roentgenogram.[8,23,86] Abdominal films of 3 patients with typical microscopic findings were observed. In no instance were the calcifications seen. Figure 3 shows the comparative densities of a normal spleen, splenomegaly due to mye-

Fig. 3. Variations in density of the spleen. *1*, case of portal and splenic vein thrombosis; *2*, iron and calcium incrusted spleen; *3*, calcified infarct of the spleen; *4*, normal spleen; *5*, myelogenous leukemic splenomegaly.

logenous leukemia, the spleen in a case of splenic vein thrombosis and the spleen of 1 of the above-mentioned 3 cases. The marked contrast in opacity between the congested and iron and calcium incrusted spleens emphasizes the improbability of visualizing a case of the latter condition on the abdominal roentgenogram.

SPLENIC ARTERY

Arteriosclerosis of the splenic artery, often accompanied by dilatation and calcification of its walls, is frequently found at the autopsy table.[11,69,77,89,100] Its frequency increases directly with the age of the individual. The artery arises directly from the celiac axis and courses laterally just above the pancreas to enter the hilus of the spleen through the phrenicolienal ligament. Immediately below lies the splenic vein, which accompanies the artery along most of its course. Both vessels receive little support from their vessel beds. As a result the artery is usually tortuous, extremely prone to undergo atheromatous changes, and suffers aneurysmal dilatations of its sclerotic walls very commonly.[83] Calcification of the altered vessel readily occurs. The calcium salts are deposited almost exclusively in the media, and the vessel often becomes calcified throughout its entire course.

Dilatation of the arteriosclerotic, calcified splenic artery occurs frequently and is variable in character. The vessel may be uniformly dilated from its origin to the spleen. More often, however, saccular and varicose aneurysms are noted. These may be single or multiple, both types occurring in approximately equal numbers. Aneurysms have been found near the origin of the artery,[50] in that part coursing superior to the pancreas,[86] near the hilus of the spleen[65,83] and in the spleen itself.[9] They vary considerably in size. While the majority are less than 3 cm. in diameter, aneurysms up to 7 cm. in diameter have been observed.[41] Calcification in the walls of the localized dilatations usually occurs simultaneously with the deposition of the calcium in the remainder of the artery. Sheet-like plaques are laid down in the media forming a complete or almost complete ring of calcification. However, although calcium incrustation of the aneurysm and the remainder of the artery tend to occur concomitantly, nevertheless the aneurysm

Fig. 4. Case of portal and splenic vein thrombosis. Note markedly increased density of the spleen.

may be calcified alone or the artery may show calcification without the dilatation being similarly affected. Arteriosclerosis and calcification of the splenic artery are frequently accompanied by similar changes in other arteries, particularly the aorta.[98,101]

Sclerotic, calcified aneurysms are usually small and show little tendency toward rupture. Larger ones are encountered occasionally, and the danger of their rupturing is much greater.[4,41] Indeed, Säfwenberg[86] stated that although the small calcified dilatations were of no clinical significance the larger ones—those above hazelnut size—might require removal to prevent possible rupture. Such an aneurysm was removed prophylactically by Lindboe.[66] Another complication, splenomegaly, has been observed to result from pressure of a large aneurysm upon the splenic vein.[78]

The roentgen appearance is usually characteristic. This has been emphasized by the various contributors on the subject.[45,50,86,97] The artery may be tortuous and calcified without local dilatations. Its roentgenogram shows a serpiginous, double linear shadow—representing its side walls—extending from the midline across the left upper quadrant into the region of the spleen.[13] When calcified aneurysmal dilatations are present they appear as ring-like shadows which are quite dense. Small sections of the circumference are frequently invisible and usually represent the sites of junction of the lumina of the afferent and efferent parts of the vessel with that of the aneurysm. The center of the circular shadow is always less dense than the periphery. Small, arc-like shadows may be seen immediately within or outside the main ring-like shadow of the calcified aneurysm. This appearance is due to the fact that the aneurysm is not absolutely circular, and as a result the calcification in the irregular walls of the dilatation is projected on the film as small arcs out of line with the main portion of the circular shadow.

The calcified aneurysm may be seen anywhere in the course of the artery, extending from its origin in the midline across the left hypochondrium into the shadow of the spleen. Parallel, double linear shadows of the calcified artery are often seen leading into and away from the dilatation. Such an appearance is pathognomonic. Concomitant calcification in the aorta is frequently observed. Occasionally, other abdominal vessels also show calcium deposition. On the other hand, only the aneurysm may have the incrustations and be visible on the roentgenogram, neither the remainder of the splenic artery nor the aorta being demonstrable. In such cases the appearance of the shadow is adequate for the correct interpretation (see Fig. 5).

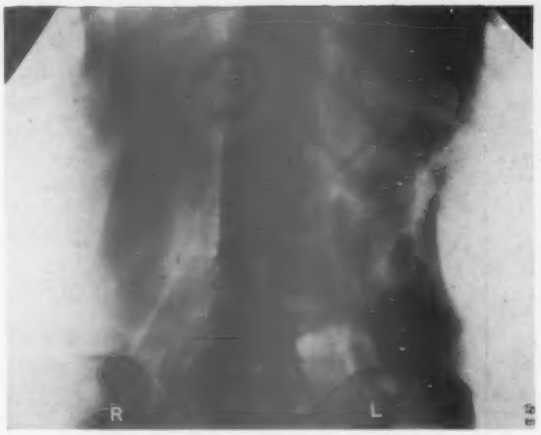

Fig. 5. Calcification in an aneurysm of the splenic artery.

Roentgenographic differentiation of the condition from a calcified renal artery and a small non-parasitic cyst of the spleen may offer great difficulty. In the case reported by Key and Åkerlund[55] a calcified aneurysm of the renal artery was observed near the midline just below the left twelfth rib. This level is somewhat below that of the origin of the splenic artery, and lies much farther within the plane of the kidney. However, since the splenic artery is prone to a tortuous course it may lie below its usual coronal plane and so offer difficulty in differentiation. Baumann and Kohnstamm[9] have published the roentgenogram of a small calcified aneurysm of an intrasplenic branch of the splenic artery. This shadow cannot be distinguished from that of a

TABLE I

ARTERIOSCLEROTIC CHANGES IN THE SPLENIC ARTERY

Case	Autopsy No.	Age	Splenic Artery	Aneurysm Formation	Aorta	Remarks
I	6546	68	Tortuous, sclerotic, calcified	None	Severe sclerosis	Heart valves calcified. Coronary arteries calcified
II	6772	82	Tortuous, sclerotic, calcified; lumen occluded	None	Moderate sclerosis	Coronary artery sclerosis; calcified infarct spleen
III	8013	58	Tortuous, sclerotic	Single, 1 cm. diameter, intrapancreatic; calcified	Slight sclerosis	Coronary artery sclerosis; calcification of heart valves
IV	8268	65	Tortuous, sclerotic, calcified	None	Moderate sclerosis	Coronary artery sclerosis
V	8643	47	Tortuous, sclerotic	Single, 1 cm. diameter, 2 cm. from spleen; calcified	Moderate sclerosis	Coronary artery sclerosis and occlusion; splenic infarct
VI	8821	40	Tortuous, sclerotic	Single, 1 cm. diameter, near hilus; calcified	Severe sclerosis, calcified plaques	Coronary artery sclerosis
VII	9003	72	Tortuous, sclerotic, calcified in areas	None	Severe sclerosis, calcified plaques	Coronary artery sclerosis; severe abdominal artery sclerosis
VIII	9061	35	Tortuous, sclerotic, calcified, thrombosed	None	Essentially normal	Splenic infarct
IX	9282	76	Tortuous, sclerotic	Single, 0.5 cm. diameter, 5 cm. from spleen; calcified	Severe sclerosis; calcified plaques	Sclerosis of other abdominal arteries
X	9883	65	Tortuous, sclerotic, calcified, thrombosed	Single, 1 cm. diameter, at hilus of spleen; calcified	Severe sclerosis; calcification	Coronary and abdominal artery calcification; splenic atrophy
XI	9937	65	Tortuous, sclerotic, calcified	Single, 2 cm. diameter, 8 cm. from spleen; calcified; thrombosed	Severe sclerosis; calcification	Coronary and abdominal artery calcification; splenic infarct

small, calcified, non-parasitic splenic cyst. Differentiation might be made only if there were concomitant calcification of the splenic artery visible on the roentgenogram.

Eleven cases of sclerotic changes with calcification in the splenic artery have come under observation. The pathological findings in these cases are listed in Table I.

Eight of the patients (72.7 per cent) were over fifty-five years of age. Seven of the 11 cases (63.6 per cent) showed calcification of a tortuous, sclerotic artery. Only 2 of the calcified arteries contained aneurysms. Both dilatations were calcified. In 6 cases (54.5 per cent) there were aneurysms pres-

ent, all calcified. The sites of the dilatations varied from a point near the origin of the artery to a location at the splenic hilus. Single aneurysms were present in each case. Their size varied from 0.5 to 2 cm. Thrombosis of the thickened, calcified vessel was observed 3 times. It occurred once within the lumen of the aneurysm. In the latter 4 cases there resulted infarcts in or atrophy of the spleen. Tortuosity of the artery was observed in all the cases. The aorta showed more or less atherosclerosis in 10 patients, and calcifications were present 5 times. Calcium depositions in other abdominal vessels and the coronary arteries were noted frequently. Splenic artery sclerosis, tortuosity and aneurysm formation without calcification were encountered in 3 additional cases.

SPLENIC VEIN

The splenic vein may occasionally show changes similar to those observed in the artery. Thus, in the cases described by Heppner[41] and Trevor[98] the vein was tortuous, dilated, thickened, varicose and calcified. Saccular, calcified aneurysms were present in each case. Similar dilatations of the intrasplenic branches of the vein are not infrequent.[54] Thrombosis of the vein without major changes in its wall has also been observed.[101] The splenic veins in the 11 autopsied cases described above showed no pathological changes in their walls.

ADRENAL GLAND

Deposits of calcium salts in the adrenal glands occur in association with tuberculosis and tumor formation in this organ.

Mascroscopic calcification in tuberculosis of the adrenal glands has been observed in 32 per cent of a series of 34 cases.[6,7] In Guttman's series of 566 cases of Addison's disease they were not infrequently observed.[35] Roentgenograms of suprarenal calcifications have been published by Schatzki,[88] Kovács,[63] and Camp, Ball and Greene.[21] The latter advise films made in the oblique position to facilitate the demonstration of these concretions. The calcifications usually appear as triangular, semilunar or oval shadows located over the median aspect of the upper pole of the kidney. The shadows are usually composed of numerous, small, dense and discrete concretions lying close together. Occasionally the gland may be grossly and completely calcified or may show a general increase in density due to diffuse infiltration by calcium salts.

Necropsy in a case of Addison's disease revealed a bilateral fibrocaseous tuberculosis of the adrenal glands. The glands were held firmly in their usual positions by many adhesions, and were not greatly enlarged. Irregular calcium deposits were observed in the right gland. An abdominal roentgenogram of this patient revealed two small collections of concretions in the right upper quadrant immediately above the kidney which were correctly interpreted as being calcifications in the adrenal.

Calcium depositions in various types of adrenal tumors have been noted by several observers. Gellerstedt and Hjelm[34] showed the roentgenogram of a boy aged six. In the liver shadow, immediately above the inner half of the upper pole of the kidney, was a large mass about the size of the kidney. The center of this large irregular shadow contained a group of calcium-dense concretions which formed a network of flecks and streaks. Autopsy revealed a ganglioneuroblastoma of the right adrenal with irregular spicules of calcium present in the tumor. Heymann[42] presented an abdominal roentgenogram demonstrating a large tumor, twice fist size, in the left hypochondrium with irregular circular calcium shadows. At operation an indeterminate neoplasm of the left adrenal was removed. The tumor possessed a capsule 2 mm. thick which was richly incrusted with calcium. Boattini[14] reported a case of a dense, homogeneous shadow in the region of the right adrenal. Autopsy revealed a primary psammoma, 3 cm. in diameter, in the right adrenal gland. Massive calcium deposition in sheet-like arrangement was present throughout the tumor.

FIG. 6. Irregular calcifications in an adrenal carcinoma.

Figure 6 shows the presence of a mass in the left upper quadrant in which are clearly demonstrated a network of flecks, small streaks and irregular circular shadows. Post-mortem examination revealed huge, bilateral, cortical carcinomata of both adrenal glands. The left adrenal weighed 2,110 grams and the right 1,650 grams. The surface of each tumor was roughened by varying sized deposits of calcium salts. Huge hepatomegaly due to spread by contiguity from the right adrenal tumor was present. The spleen weighed 475 grams and showed only passive congestion. Neither the liver nor spleen showed calcifications.

PANCREAS

Radiopaque concretions in the tail of the pancreas have been observed only rarely,[57] but may be confused with intrasplenic shadows when they do occur.[47]

Pancreatic lithiasis is predisposed by stasis and infection. Normal pancreatic secretion contains no calcium. However, with the presence of infection there is an altered secretion and, as in many inflammatory processes, the tendency for the deposition of calcium salts.[1,90] The calculi are almost invariably formed in the ducts, particularly in the main duct near the entrance into the duodenum. Stone formation also occurs, but with less frequency, in duct cysts and abscesses. The presence of a calculus at the head of Wirsung's duct leads to a marked dilatation of all the pancreatic channels distal to the concretion, an interlobar pancreatitis and finally, marked fibrosis. The obstructed and greatly dilated pancreatic ducts may form cysts in the fibrotic organ. Additional calculi may develop within the duct cysts. The stones are usually radiopaque, consisting chiefly of calcium carbonate and calcium phosphate. Rarely they contain only small amounts of calcium and are radiotranslucent. The calculi vary in size from less than 1 cm. to about 4 cm. in diameter. They are rough, irregular, sometimes jagged, and the larger ones may assume a stag-horn appearance because of projections into larger ducts. When multiple, the stones are frequently faceted. They may be situated anywhere in the pancreas from the head, near the midline, to the juxtasplenic tail.

In 5 of the 114 cases of pancreatic lithiasis reported up to 1937, the diagnosis was first made from the abdominal roentgenogram.[44] Friedrich and Hoesch[32] reported a case of multiple, faceted, dense concretions in the left upper quadrant which greatly resembled gallstones. Hoechstetter's abdominal film showed numerous, similar, faceted concretions extending from the spine high up into the left upper abdomen in a more or less linear fashion. Clusters of multiple concretions were observed by Bost[15] near the first lumbar vertebra and in the splenic region due to stones in the head and tail of the pancreas. Multiple, indefinite, irregular shadows of heterogeneous density were noted in the upper abdomen by Lindsay[67] and Ackman and Ross.[1] Cases of radiotranslucent pancreatic calculi have been reported by Seeger[90] and Rienhoff and Lewis.[82]

Radiopaque lithiasis of the pancreas is most often confused with calcifications in mesenteric lymph nodes, renal calculi[15] and intrasplenic calcifications. Of great assistance in the diagnosis is the cognizance of the existence of the condition in patients who complain of colicky epigastric and

back pain, marked wasting, fatty stools, nausea, vomiting, jaundice and skin pigmentation. Examination of the abdomen may reveal irregular opacities extending anywhere along the course of the pancreas from the midline to the spleen. Differentiation from renal calculi may be aided by urographic studies. Calcified abdominal lymph glands may be excluded with the aid of the clinical history, the absence of pulmonary tuberculosis, a negative tuberculin test and films taken in the upright and lateral recumbent positions to establish the mobility of the concretions. The Potter-Bucky diaphragm should be used wherever possible since roentgenograms made without it have failed to demonstrate concretions that were present.

Of extreme rarity is the presence of calcium deposits in a malignant neoplasm of the pancreas.

A white male, aged forty-two, was admitted with a six months' history of left loin pain radiating to the left groin. He had lost 49 pounds during the preceding four years. Physical examination revealed an enlarged, ballotable spleen in the left upper quadrant. A roentgenogram of the chest showed calcified nodules in the lungs. On the abdominal roentgenogram (Fig. 7) a large, ill-defined mass in the splenic region was observed. In the center of this shadow could be seen a network of moderately dense concretions in the form of flecks and small threads. There were no round, dense, individual concretions usually seen in tuberculous splenitis with calcified tubercles. Post-mortem examination revealed a huge tumor of the body and tail of the pancreas which had grown upward into the left upper quadrant under the diaphragm and had displaced the spleen downward. Gross, irregular and streaky calcifications were observed within the neoplasm. The spleen was spotted, only slightly enlarged and contained no calcifications. An adhesive, non-tuberculous perisplenitis was present.

Fig. 7. Irregular, coral formation of calcium deposition in carcinoma of the pancreas.

RETROPERITONEAL TISSUES

Calcifications occurring in pathological processes of the retroperitoneal connective tissues have been observed rarely. The conditions usually encountered are tuberculosis[86] and new growths. Hultén[49] reported a case of tuberculous peritonitis which became arrested and went on to diffuse intra-abdominal calcifications. Calcific masses appeared in the pouch of Douglas, the lower abdomen, abdominal lymph glands and in the retroperitoneal fatty tissue high up in the left upper quadrant. The latter concretions were round and dense, greatly resembling calcified tuberculous nodules in the spleen. Differentiation was aided by the presence of the numerous other intra-abdominal calcium shadows.

Calcifications in retroperitoneal sarcoma have been observed by Klemperer.[57] One such case was observed at the Mount Sinai Hospital. An abdominal roentgenogram of a white male, aged sixty-two, with a palpable left para-umbilical mass revealed a large dense shadow in the left side of the abdomen. Within the shadow, and immediately adjacent to the renal outline, were

TABLE II

ROENTGENOGRAPHIC APPEARANCE OF CALCIFICATIONS IN THE SPLEN'C REGION

Calcification	Location	Number	Size	Shape	Density	Regularity of of Outline	Age of of Patient	Remarks
Phleboliths	Intrasplenic	Few to many	Usually up to 0.5 cm. in diameter	Round	Moderate to very dense and homogeneous	Regular	Usually over 50 years	May be impossible to differentiate from small healed calcified tubercles, or calcified encysted *Pentastoma* larvae
Active tuberculosis	Intrasplenic	Moderate	Small to 3 cm. in diameter	Round	Dense	Small are regular, large are often irregular	Most during youth	Enlarged spleen with an irregular, coarsely nodular surface. Other evidence of hematogenous tuberculosis
Inactive tuberculosis	Intrasplenic	Usually moderate	Less than 0.5 cm. in diameter	Round	Moderate to dense	Regular	Usually under 40 years	Spleen small or normal; possibly evidence of tuberculosis elsewhere
Pentastoma	Intrasplenic	Usually few	Vary to 0.5 cm. in diameter	Round	Moderate to dense	Regular	Any age	Similar calcifications may be seen in liver and kidney
Perisplenitis	In splenic shadow but may extend beyond it	Usually single	Large	Irregular	Dense and homogeneous	Usually regular	Any age	Plaque-like appearance of the calcification. Moves with respiration
Infarct	Intrasplenic	Usually single; may be double	Small to large	Triangular with apex at hilum or oval	Dense and homogeneous or porous	Usually regular. May be irregular due to partial absorption	Usually past middle age	Small ones may be indistinguishable from phleboliths, etc.
Echinococcus cysts	Intrasplenic or extrasplenic (pedunculated)	Single	Usually large	Usually an incomplete ring of single or double contour containing within its circumference a varying number of ill-defined, irregular concretions	Only moderately dense periphery. Center only slightly denser than surrounding soft tissues	Circle of calcification usually regular	Any age	The spleen is enlarged. May present other evidence of echinococcus infestation. Seen more frequently in patients living in sheep and dog containing countries. Echinococcus fixation test, eosinophilia, etc.
Non-parasitic cysts	Intrasplenic	Single	Usually large	Complete ring of calcification up to 3 mm. in thickness; no concretions in center	Very dense. Center appears somewhat less dense than periphery	Regular	Any age	Spleen not necessarily enlarged. Very difficult to distinguish from moderately large intrasplenic calcified aneurysms of the splenic artery

Splenic artery and vein	Left upper quadrant from midline to spleen	Single, or artery and vein together; each appears similar to other	Artery and vein each appear as a pair of parallel lines about 0.5–1 cm. apart; length varies	Extremely tortuous course from midline to splenic area; appear as tortuous parallel lines	Varies from moderate to dense	Regular	Usually over 60	Calcification of vein practically never occurs before that of artery. Artery appears first—outline of vein may give an additional double line. Calcified aneurysms may appear anywhere along the course of the artery or vein
Aneurysms of splenic artery and vein	Left upper quadrant from midline to intrasplenic shadows	Single or multiple	Usually less than 3 cm. in diameter; may go to 7 cm. in diameter	Ring-like shadows usually bordered with arc-like shadows; center less dense than periphery	Dense	Usually tends to be regular	Usually over 60	Artery much more frequent than vein. May show double linear shadow of calcified vessel leading to and from it. Aorta often shows calcification
Adrenal gland tuberculosis	Left upper quadrant immediately above median aspect of upper pole of kidney; may be bilateral	Usually a group of small concretions	Varies to about 2 cm.	Usually a triangular or semilunar cap	Dense	The group of small dense concretions usually has a regular outline	Usually before middle age	No evidence of a mass. Evidence of tuberculosis elsewhere. Addison's disease usually present
Pancreatic lithiasis	Extends from right side of 1st and 2nd lumbar vertebrae across left upper quadrant to hilus of spleen	Few to many	Vary up to about 2 cm. in diameter	May be round, faceted, or irregular	Dense and homogeneous	Usually regular or faceted; may be irregular	Any age; usually middle age	History of indefinite epigastric and back pains, jaundice, weight loss, diabetes, steatorrhea, etc.
Tumors of body of pancreas, adrenal and retroperitoneal tissues	Left upper quadrant	Many	Varies greatly	Usually irregular network of flecks and small threads in coral formation present within a large non-calcified irregular mass	Moderately dense and heterogeneous	Irregular and shreddy	Usually middle age	The characteristic coral formation of the calcifications is most frequently seen in malignant tumors of these tissues. Other types of calcification occur, but are seen much less frequently
Abdominal lymph glands	Throughout abdomen, including splenic region	Usually multiple, frequently in clusters; occasionally single	Vary up to 2 cm. in diameter	Irregularly round or oval	Dense and heterogeneous	Irregular and nodular	Any age	Usually mobile. Rarely within the splenic shadow
Renal artery	Usually in left paraumbilical region	Usually single	Varies up to 2 cm. in diameter	Round and ring-shaped with central translucency representing lumen of vessel	Moderately dense	Regular	Usually past middle age	Usually near hilus of kidney. When tortuous may appear in splenic region

mesh-like formations of moderately dense, small irregular concretions. The appearance was not unlike that of coral. At autopsy a large retroperitoneal sarcoma containing irregular, macroscopic calcifications was found.

Of considerable importance is the frequency with which irregular calcifications in the various tumors, usually malignant, appear on the roentgenogram as a network of flecks and streaks. The same appearance may be observed regardless of the type or site of the neoplasm. Thus, similar roentgen pictures have been noted in such growths as adrenal carcinoma and ganglioneuroblastoma, pancreatic carcinoma and retroperitoneal sarcoma. While other types of calcifications may occur they are not as frequent or apparently as characteristic as the coral formation described above.

MISCELLANEOUS

A number of miscellaneous calcifications may be observed at times in the splenic region. The elongated, multiple rather homogeneous shadows of varying width which follow along the courses of the costal cartilages are usually characteristic of calcifications in these cartilages. In doubtful cases an oblique view will establish the anterior location of the concretions. Lateral and oblique views are also of great assistance in the localization of shadows in the lungs, pleura and abdominal wall musculature. Calcified lymph nodes characteristically cast dense, heterogeneous shadows whose borders have small, irregular nodulations. They tend to be irregularly round or oval in shape and are frequently multiple. They usually vary up to about 2 cm. in diameter. Since they are often at least somewhat mobile, films taken in various positions may be essential in differentiating these concretions from other fixed shadows. Calcification in renal vessels has been described in the section on splenic vessel calcifications. At times they may be extremely difficult to distinguish from calcium-incrusted lienal vessels or other intra-abdominal concretions.

Ingested radiopaque material in the stomach or upper intestine may appear as confusing left upper quadrant concretions on the roentgenogram. Extremely dense, homogeneous, round or oval shadows have been observed in the splenic region after the ingestion of iron pills, enteric coated ammonium chloride capsules, etc. Films taken at a later time demonstrated the nature of these concretions, and their movement down the intestinal tract.

Nevi, papillomata and melanomata of the skin may cast dense shadows on the roentgenogram which usually tend to be round and have regular outlines.[86] Examination of the patient reveals their presence.

CONCLUSION

The difficulties in interpretation of the many calcifications which appear in the splenic region are manifest. It has been the purpose of this paper to aid in the classification and differentiation of the concretions observed in this area. A brief résumé of the salient features in the differential diagnosis of the various conditions may be found listed in Table II.

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HISTOLOGICAL STUDIES OF THE LIVER, SPLEEN AND BONE MARROW IN DOGS FOLLOWING THE INTRAVENOUS INJECTION OF THORIUM DIOXIDE*

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INTRODUCTION

IN SEPTEMBER, 1933, we reported before the American Congress of Radiology the results of our studies of the liver, spleen and bone marrow in rabbits following the intravenous injection of thorium dioxide.[3] We reached the conclusion that 0.5–1.0 cc. of thorotrast per kilogram of body weight is tolerated by these animals without evidence of immediate injury. The radiopacity manifested itself from fifteen to forty-five minutes after the injection. It lasted in the spleen for as long as 493 days (our longest period of observation) without noticeable reduction in density. The thorotrast was seen in the reticulo-endothelial cells of the liver, spleen and bone marrow, and scattered in fine granules throughout the liver cells. The early changes in the liver were hydropic degeneration, edema of the portal spaces and dilatation of the periportal lymphatics. Later there was usually recovery from the hydropic degeneration and a slight but definite increase in connective tissue. In the spleen, an early change simulating acute splenic tumor occurred, followed later by slight fibrosis in the majority of cases. The bone marrow underwent hyperplasia early, which was replaced eventually by exhaustion, manifesting itself by a partial disappearance of the blood-forming centers and serous atrophy of the fat. We concluded, therefore, that the intravenous injection of thorotrast for diagnostic purposes should be restricted to incurable cases until evidence to the contrary should be presented based on studies in the human, demonstrating without doubt that the changes observed by us in rabbits are not significant.

Because of our desire to extend the period of observation following the injection of the thorotrast and also because of the fact that some investigators did not agree with the interpretation of our findings,[4] we undertook a second series of experiments but chose dogs for the work because of the greater stability of this animal. Since the completion of these studies numerous publications dealing with the subject both from an experimental and clinical standpoint have appeared; for a review of the literature the reader is referred to a recent paper by Orr, *et al.*[2]

TECHNIQUE

The same procedure was used as in our previous investigations. One cubic centimeter of the thorotrast solution per kilogram of body weight was injected undiluted, as furnished by the manufacturer, into the great saphenous vein of 7 female dogs. One animal died fifteen days after the injection; since the autopsy did not reveal any relation between the injection and the death this dog could not be included in the series beyond the statement that the roentgenographic findings were the same as in the other animals who survived. The dogs were kept in the same kennel under identical living conditions and killed two years or later following the injection. Roentgenograms were taken at regular intervals during that period. Portions of the liver, spleen, lymph nodes, kidney and bone marrow were removed for microscopic ex-

* The valuable assistance of E. E. Seedorf, M.D., formerly research assistant in the Department of Radiology, is hereby gratefully acknowledged.

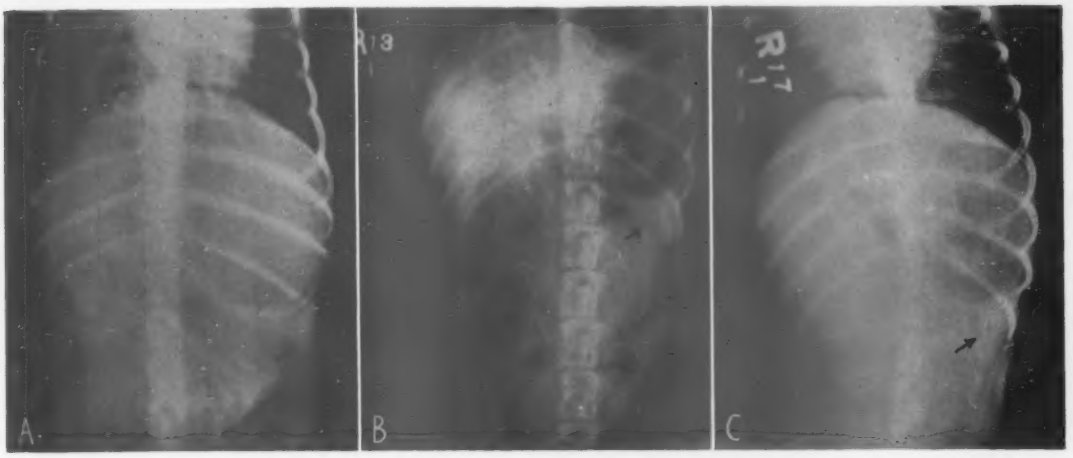

Fig. 1. Roentgenograms of dog No. 1 taken fifteen minutes (*A*), 384 days (*B*) and 805 days (*C*) after injection. Arrows point to spleen.

amination. The amount of dye injected and the interval between injection and killing of the dogs are shown in Table 1.

Table I

Dog No.	Dye, cc.	Observation Period
1	9.2	806 days
2	7.6	15 days*
3	6.1	785 days
4	6.5	765 days
5	6.0	765 days
6	7.3	754 days
7	7.0	754 days

* Died from unknown cause.

OBSERVATIONS

1. *Roentgen Studies.* The liver and spleen were visualized definitely in the roentgenogram from fifteen to sixty minutes after the injection. We cannot explain this variation in the time required for rendering the organs radiopaque because the same amount of thorotrast per kilogram of body weight was injected in all cases. Since the roentgenographic findings were the same in all dogs we chose the animal with the longest observation period (No. 1) for illustration. It appears that there is little loss of density in liver and spleen comparing the roentgenograms taken fifteen minutes, 384 and 805 days respectively after the injection.

2. *Histological Studies.* The histological findings were almost identical in all cases, so that a detailed description of the changes found in each animal is unnecessary. Also, the only organs showing changes which could be ascribed to the injection of thorium dioxide were the liver, spleen and bone marrow; descriptions of other organs are therefore not included.

Liver. Many thorotrast-filled phagocytes were seen, irregularly arranged with refer-

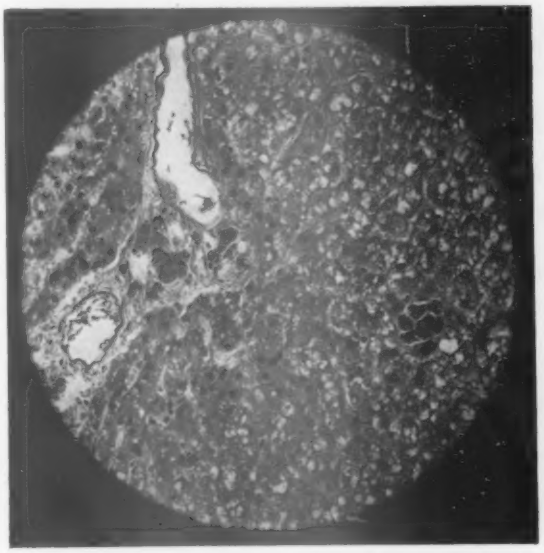

Fig. 2. Photomicrograph of liver. Note the thorotrast in the periportal connective tissue on the left and one group of phagocytes in the sinusoid on the right.

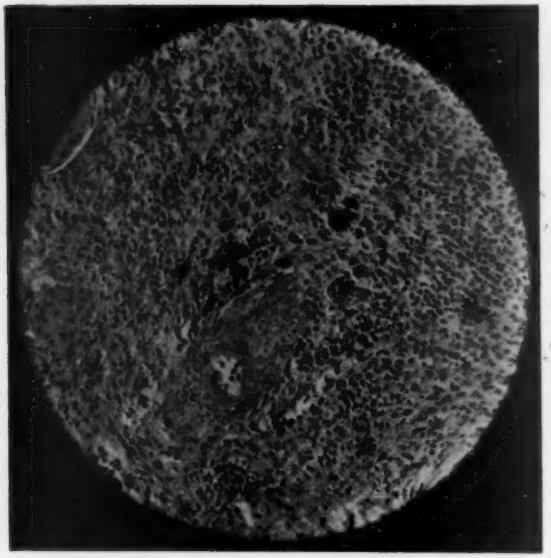

Fig. 3. Photomicrograph of spleen. The dye-containing phagocytes are grouped about a trabecula.

ence to the hepatic architecture (Fig. 2). Some were in the sinusoids, and appeared to be Kupffer cells which had remained *in situ* after engulfing the dye. Others were situated in the periportal connective tissue, which, however, was normal in amount. In every case there was well-marked vacuolar degeneration in the liver cells.

Spleen. Thorium dioxide was present in abundance, within phagocytes and situated in the pulp (Fig. 3). In some areas the dye was found along the connective tissue trabeculae. The malpighian corpuscles were normal in appearance, but the pulp was congested and slightly hyperplastic. The pulp showed localized areas of fibrous thickening of the framework, which seemed to have no relation to the thorium.

Bone Marrow. This was taken from the mid-femur in every case. The microscopic picture was normal, except for an occasional reticulo-endothelial phagocyte which had engulfed a small clump of thorotrast particles (Fig. 4).

No evidence of impairment of the general health could be observed over a period of two years. No decrease in the radiopacity of the spleen and liver was noted during the experiment, and there was no evidence microscopically that any thorium dioxide had been eliminated.

COMMENT

These results differ considerably from those obtained by us formerly, using rabbits as subjects. We could not detect thorotrast in any tissues of our dogs except the spleen, liver and bone marrow. The spleen was the site of slight diffuse fibrosis, and the liver of vacuolar (hydropic) degeneration. No fibrosis was seen which could be interpreted as a foreign body reaction. Neither could we find the "thorium necrosis" described by Naegeli and Lauche[1] as observed in the mesenteric lymph nodes of one dog three years after injection. The only evidence of damage in the dogs used was the vacuolar degeneration of the liver, which was interpreted as being due to the radioactivity of thorotrast. Such a change occurs early in the rabbit, to be followed by fibrosis. In contrast to the severe bone marrow damage and the less severe splenic damage found in the rabbits in our series, the marrow and spleen of our dogs showed no lesions which could be ascribed to the presence of thorotrast.

Two explanations may be offered for

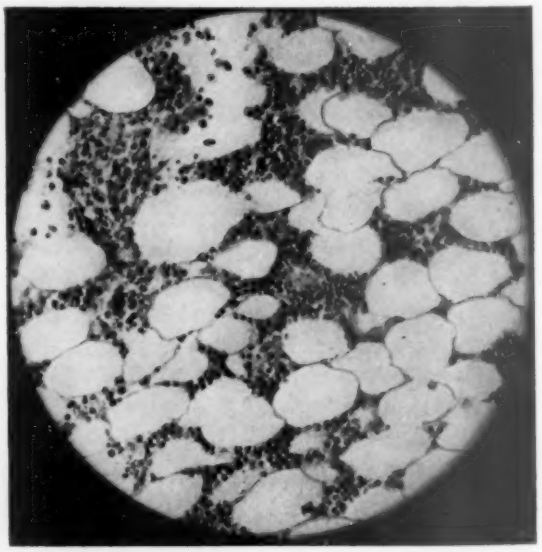

Fig. 4. Photomicrograph of bone marrow. No pathologic changes; a few particles of thorotrast are seen in single phagocytes.

this difference. First, the thorotrast may have been in different stages of disintegration in the two experiments, so that its radioactivity and hence its effect differed. It is impossible to clarify this point, as we had no means of identifying and tracing the different lots of dye used. Secondly, the difference in reaction might be due merely to a greater susceptibility to such agents on the part of rabbits. In our opinion this latter factor is the chief one, although it is admitted that the former cannot be discarded completely.

SUMMARY AND CONCLUSIONS

1. Seven dogs were injected intravenously with 1 cc. of thorotrast per kilogram of body weight and killed two years after the injection. One animal died from unknown cause fifty days after the injection, leaving six dogs for study.

2. Roentgenograms taken at certain intervals during the period of observation did not show any appreciable loss in density of liver and spleen.

3. The only histological changes referable to the presence of thorotrast consisted of vacuolar (hydropic) degeneration of the liver cells.

4. We consider a difference in susceptibility to be responsible for the much more pronounced histological changes found in rabbits as compared with those in dogs.

5. We still feel that the use of thorotrast for visualization of liver and spleen in humans should be definitely restricted. A critical analysis of the literature seems to support this contention.*

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* Since submitting this paper for publication, Jacobson and Rosenbaum (*Radiology*, 1938, *31*, 601) reported a case in which 75 cc. of thorotrast was injected intravenously five years before death. They found fibrosis in the liver, spleen and a hepatic lymph node. The approximate gamma-ray activity of the liver ash was 0.3 microgram of radium. It is considered likely that the pathologic changes noted were caused by the presence of thorium in these organs for a long period of time, and not to antecedent disease.

PHYSIOLOGICAL EFFECTS OF RADIATION

II. THE *IN VITRO* LETHAL SINGLE MASSIVE ROENTGEN-RAY DOSE (AT 200 KV.) FOR THE BROWN-PEARCE RABBIT EPITHELIOMA*†

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BEFORE studying the *in vivo* effect of combining roentgen-ray and infra-red radiation upon a transplantable tumor (Brown-Pearce rabbit epithelioma), it is necessary to find the lethal effect of each of these radiations upon the tumor cells alone, neglecting as far as possible any reaction on the part of the host. The *in vitro* lethal effect of infra-red radiation alone upon these tumor cells has been tested by exposure in a constant temperature water bath and by inoculation of the treated cells into rabbits. This has been described in Part I of this series.[2] The following experiments were undertaken to find the lethal *in vitro* massive roentgen-ray dosage for this tumor.

Wood and Prime[7] studied the amount of both gamma rays, and gamma and beta rays necessary to kill or to damage all of the tumor cells *in vitro* in transplantable mouse and rat tumors (Flexner-Jobling rat carcinoma and mouse sarcoma 180 and 11 of the Crocker fund series). In their first experiments, no attempt was made to correlate the skin erythema dose with the dose required to inhibit growth. In a later paper Wood and Prime[8] found that 5 or 6 erythema doses of roentgen rays (90 kv. with 3 mm. Al filter) were necessary to inhibit growth of the mouse sarcoma cells upon transplantation. In a similar manner, they found that 4 erythema doses would produce death of the rat carcinoma cells in tissue cultures *in vitro*, while 6 erythema doses given to the tumor *in situ* before transplantation were required to prevent subsequent growth in new hosts. Murphy, Maisin and Sturm[4] pointed out that a single skin erythema dose of roentgen rays given directly to a transplantable tumor produced little if any effect on the growth characteristics of the tumor when re-inoculated into new tumor-susceptible hosts. Hill, Morton, and Witherbee[1] showed that sublethal doses of roentgen radiation (8 inch gap) temporarily checked the growth of transplantable tumors (Bashford adenocarcinoma 63), but that the tumors subsequently almost recovered their normal rate of growth.

Packard[5] irradiated mouse sarcoma 180 with both high and low voltage roentgen rays and concluded that the lethal dose was around 2,700 r. He also concludes that both high and low voltage roentgen radiation are equally effective. Sugiura,[6] using roentgen rays generated at 200 kv., found the lethal dosage for mouse sarcoma 180 to be 2,800 r. Lawrence, Horn, and Strong[3] irradiated a theelin induced mouse mammary adenocarcinoma with different doses of filtered 200 kv. roentgen rays and determined the lethal dose to be approximately 4,500 r.

It seems timely to extend the *in vitro* experiments cited above with dosage measured in standard roentgens both for the purpose of our own comparison of destructive effects and to demonstrate the relatively high dosage required to kill the Brown-Pearce rabbit epithelioma *in vitro*. Since this tumor is highly malignant when inoculated into the testis, it is possible to observe damage to the tumor cells by changes produced in the percentage of takes, the rate of growth, the latent period between inoculation and growth of the tu-

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† Supported by a grant from the International Cancer Research Foundation.
‡ Part of this material was submitted for a Master's Thesis, June, 1936.

mor to a palpable size, and the length of life of those animals in which death occurred from cachexia.

METHOD

In order to encompass the variation of *in vitro* experiments, three different methods were employed at first:

Method A: A mass of actively growing, untreated tumor tissue was removed aseptically from a tumor-bearing rabbit. The tumor tissue was cut into small fragments and placed in sterile physiological saline in two Petri dishes. One dish of fragments was kept at room temperature as a control, while the other dish was irradiated. The radiation factors for all the experiments were as follows: 200 kv. (peak), 25 ma., filter 0.5 mm. Cu plus 1 mm. Al, 28 cm. target-tumor distance, 165 r per minute. The reading in roentgens was determined by a Victoreen r-meter by placing the ionization chamber inside of a broken Petri dish. In this way, it was possible to take into account the filtration effect of the cover, the back-scatter due to the Petri dish itself and the table upon which it was placed. The tumor fragments were given a dose of 2,000 r after which a number were removed and inoculated at once into both testes of young adult male rabbits. The dish of fragments was again irradiated, receiving this time an additional 1,000 r. A number of the tumor fragments which had received 3,000 r were then removed and inoculated at once into other young adult male rabbits. Finally, the remaining fragments in the Petri dish were again irradiated with 1,000 r, so that all of the remaining tumor tissue received a total of 4,000 r. These fragments were inoculated immediately into young adult male rabbits. Lastly, tumor fragments from the control Petri dish were inoculated. Any destructive effect due to standing outside of the body would then be taken into account since the controls had remained outside of the body for a slightly longer time than had the irradiated fragments.

Method B: A large, actively growing untreated tumor mass (approximately 2 cm. in diameter) was removed aseptically and divided into two equal parts. Each half was placed in sterile physiological saline in separate Petri dishes. One half was allowed to stand as a control at room temperature, while the other half was irradiated using the same roentgen-ray factors as above. After a dose of 2,000 r had been given to this half, a portion of the outside translucent material was removed. This material was then divided into fragments and inoculated into both testes of young adult male rabbits. The remaining mass was then given an additional 1,000 r when another portion of the actively growing periphery of the mass was removed and used for inoculation. Finally, the tumor mass was irradiated again and after having received a total of 4,000 r, some of the actively growing portion was cut into fragments and transplanted. Thus rabbits were inoculated with tumor receiving 2,000, 3,000, and 4,000 r, and unirradiated tumor that had been allowed to stand outside of the body for a time equal to that of the irradiated tumor.

Method C: It seemed desirable that the tumor should be outside of the body for the shortest possible time, so it was decided to irradiate the tumor *in situ*. In order to calibrate the dosage, the ionization chamber of the Victoreen r-meter was placed along side of the testes of 3 tumor-bearing rabbits between the penis and scrotum and centered as nearly as possible to the center of the tumor. The testes were centered in a field 15 cm. in diameter. These rabbits were not used in these experiments. For the experiment, untreated rabbits of the same stock and size which had previously been inoculated in both testes, and in which the tumor had shown a good rate of growth were used. The rabbits were tied down on a board and irradiated. The left testis was removed under local anesthesia after the first irradiation and the tumor transplanted. The right testis was then given an additional 1,000 r and was in turn removed and transplanted. The dosage range between 2,000 and 6,000 r was investigated in this manner. Since the same tumor tissue could not be used as a control, stock tumors of the same tumor generation were transplanted on the same day by the same technique into similar stock.

In order to ascertain whether there was any delayed tumor growth in those rabbits in which the tumor failed to take, they were observed for a period of at least sixty days, and in many cases, for as long as 200 days.

To prove that the failure of tumor growth was not due to some refractory factor in the host but to the irradiation of the tumor cells, some of the rabbits in which growth of the irradiated tumor did not occur were later inoculated with untreated tumor fragments in order to test their susceptibility to this tumor. None was found refractory.

DISCUSSION OF RESULTS

The results of this experiment may be considered from four points of view, i.e., percentage of takes, latent period, rate of growth as indicated by the actively growing period, and length of life. *The percentage of tumor growth or takes* (Fig. 1 and Tables I and II) resulting from the inoculation is the most important point in this study, since it is possible to compare the lethal effects of various doses of *in vitro* radiation in a larger group of animals than was available for the other evidences of tumor damage, i.e., length of life, latent period, and rate of growth. The percentage of takes in the control group of rabbits for this group is very well defined, for in this laboratory, over a thousand rabbits have been inoculated with the result that the tumor has grown in approximately 98 per cent of normal young adult stock male rabbits. Since the rabbits used in these experiments were young bucks from our usual stock, we would, from our control data, expect about 98 per cent of the grafts to grow. In the 26 actual controls used, all of the fragments grew so that we can postulate that the tumor and animals were suitable for the experiment.

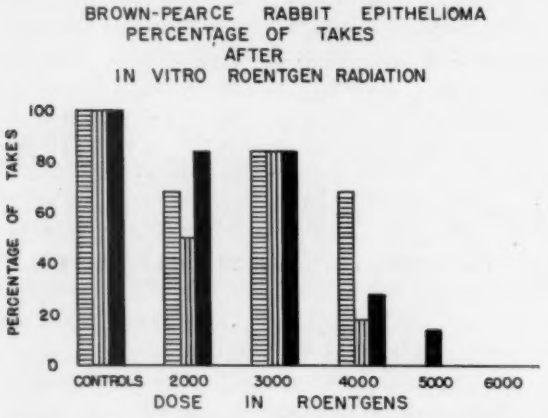

FIG. 1. The percentage of takes is plotted against the dose in roentgens. Horizontal lines, Method A; vertical lines, Method B; solid black lines, Method C.

All of the tumor transplants that were irradiated, regardless of how the radiation was given and regardless of the amount, "took" in less than the expected 98 per cent (Tables I and II and Fig. 1), the highest percentage of takes being for Method C at 2,000 r, and in all three methods at 3,000 r 83.5 per cent grew. Since the number of tumors inoculated in groups A and B at 3,000 r and 2,000 r was so small (6 each), one failure would influence the percentage of takes a great deal (17 per cent). We believe however that this falls within the normal biological variation, and since we are interested in the end-point of lethal effect, it does not seem important to fix the percentage at this level by a larger series. Since all three methods give the same percentage of takes at 3,000 r, it would appear that the value of 83 per cent of the tumors growing, i.e., a total of 25 tumors in 30 transplants (Methods A, B, and C), is probably significant.

The percentage of takes diminishes at 4,000 r very perceptibly, i.e., a total of 10 out of 30, or 33 per cent (Methods A, B, and C), and at 5,000 r (Method C alone) the number of viable grafts is markedly diminished, i.e., 3 out of 22, or 13.6 per cent, while at 6,000 r (Method C only) no growth occurs at all, i.e., none in 30 grafts. Since the method used seemed to have no influence upon the outcome of the experiments up to 4,000 r, Method C was amplified considerably in the number of animals used and especially for the 5,000 r and 6,000 r groups where it was used exclusively to obtain the end-point. These results are graphically shown in Figure 1.

It would seem that certain cells in a tumor mass are more sensitive to radiation than others, for with a dose of 5,000 r some of the cells are still able to survive and grow, while with a dose of 2,000 and 3,000 r relatively few of the cells have been irreparably damaged. However, this may not be due to the irradiation entirely, although it is quite evident that the irradiation plays a major rôle in the process. Some of these results may possibly be explained by uncontrollable variations in the method of inoculation. This error is probably very infrequent. Since the factor of host refractori-

TABLE I

BROWN-PEARCE RABBIT EPITHELIOMA IN VITRO IRRADIATION

(200 kv., 0.5 mm. Cu, 1.0 mm. Al, Filter)

Rabbit No.	Dosage	Latent Time (days)		Survival Time (days)	Survival Time Minus Latent Time (days)	Rate of Growth of Testis Tumor
		Right	Left			
799	2000 r A	10	10	48	38	Both moderate
801	2000 r A	10	10	64	54	Both moderate
823	2000 r C	10	10	54	44	Right rapid; left slow
824	2000 r C	14	10	41	27 31	Both moderately rapid
802	3000 r A	10	10	80	70	Right moderate; left slow
804	3000 r A	16	16	55	39	Both moderate
811	3000 r B	16	16	45	29	Both moderately rapid
812	3000 r B	16	16	95	79	No growth in right; left slow
813	3000 r B	16	16	44	28	Both moderately rapid
826	3000 r C	17	17	60	43	Right moderately rapid; left slow
827	3000 r C	17	17	59	42	Both moderately rapid
828	3000 r C	17	17	84	67	Both slow
840	3000 r C	18	18	66	48	Both moderate
843	3000 r C	11	11	50	39	Right rapid; left moderate
805	4000 r A	38	—	78	40	Right slow
807	4000 r A	16	16	56	40	Both slow
831	4000 r C	31	—	102	71	Very slowly
833	4000 r C	18	18	56	38	Right slowly; left rapid then static
834	4000 r	18	—	55	37	Quite rapid
846	5000 r C	—	25	72	47	Moderate
849	5000 r	18	18	68	50	Slowly
Controls (average of 18 animals)		7	Not inoc.	45	25–65 38 average	Rapid

A = Method A; B = Method B; C = Method C.

ness to the tumor has been ruled out by subsequent inoculation of most of the rabbits in which the irradiated tumor failed to grow, it seems safe to disregard this factor. Any variation in the dosage in roentgens can also be disregarded for the dose was

TABLE II

BROWN-PEARCE RABBIT EPITHELIOMA

Averages

Method	Dosage	Cases	Takes per cent	Average Latent Period days	Average Latent Period for 3 Methods	Average Actively Growing Period days
A	Controls	4	100	7		48
B		4	100	7	6.92	46
C		18	100	6.9		45
A	2000 r	6	66.6	10		56
B		6	50.0	17	12.6	111+
C		6	83.5	11		60
A	3000 r	6	83.5	13.6		76
B		6	83.5	16.0	14.8	45
C		18	83.5	14.8		51
A	4000 r	6	66.6	21.5		40
B		6	16.6	38	27.6	
C		18	27.7	23.4		54
C	5000 r	22	13.6	20.3		48
C	6000 r	30	0.0	—	—	—

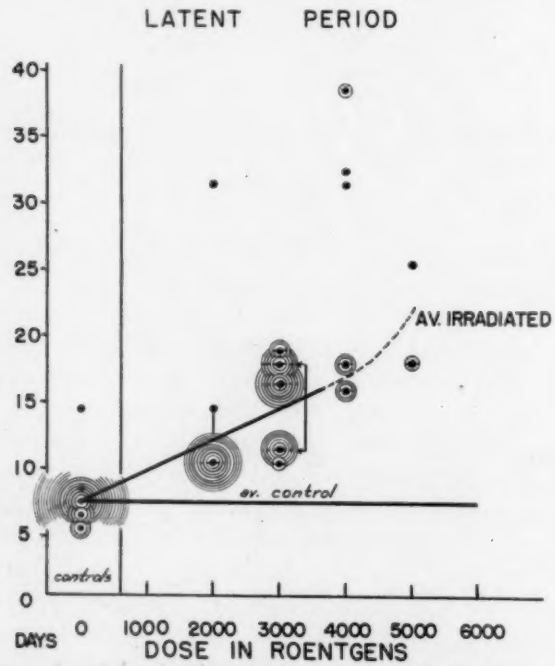

FIG. 2. The latent period in days plotted against the dose in roentgens. Lines between points indicate the latent period of transplants into the same rabbits.

controlled as well as possible by the use of a calibrated Victoreen r-meter, and in some cases, Methods A and B were run in parallel in the same Petri dish at the same time.

Analysis of Figures 2 and 3 and Table 1 indicates that the *latent period* is quite closely correlated with the amount of radiation received by the tumor. This agrees in general with the conclusions of Hill, Morton, and Witherbee[1] for Bashford adenocarcinoma 63. The higher the dose given, the longer the latent period became (where any growth occurred at all). This was true of all of the tumors that grew irrespective of the method by which they were treated. This can be explained by two viewpoints. Either the number of cells surviving after the irradiation was so markedly diminished that it took a longer period of time for the volume of the tumor to grow to a palpable size, or else the cells were so deranged in their functions that their rate of reproduction was diminished at first; thus the sur-

viving tumor took a longer time to reach a palpable size.

The *length of life* of the animal increases as the dose of radiation increases (Fig. 4). Since the average length of life of those 10 animals developing tumor which survived irradiation with 3,000 r is 63.8 days as compared to forty-five days for the controls, and since the error is probably within 10 per cent, there seems to be a definite increase in the length of life of those animals dying of tumor which had been irradiated *in vitro*. The length of life for those animals receiving tumor irradiated with 5,000 r is rather an uncertain end-point since only 2 rabbits receiving tumor given this amount of radiation developed viable tumors causing death (sixty-eight days and sacrificed at seventy-two days)—see also Table 1.

The change in volume of all of the treated tumors at first is much slower than that

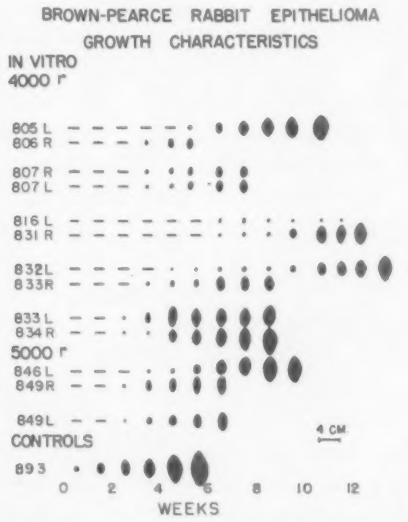

Fig. 3. Actual size of transplanted tumor after inoculation (reduced to one-fourth size). The bar indicates that there is no palpable growth. Death occurred at the end of the charted period.

of the controls. However, in many cases after the growth is well started there is little or no difference in the *rate of growth* between the various groups of irradiated tumor transplants regardless of the dose received (Fig. 3). This would, we believe, support the idea of cellular damage with *practically complete recovery of the growth characteristics in subsequent cell generations* in the growing tumor mass in such cases. On the other hand, the average values of the length increase per week are decreased materially, chiefly by the slow initial growth

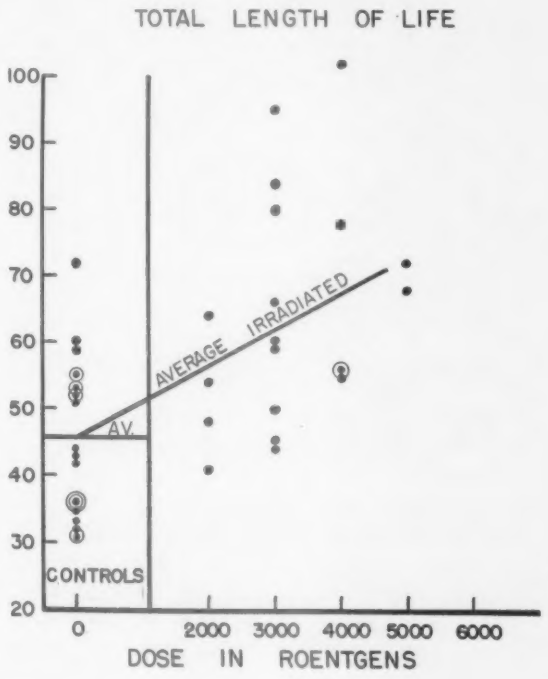

Fig. 4. Length of life in days after inoculation of the tumor, plotted against the dosage of radiation (*in vitro*).

rate and the occasional tendency of growth to slow down during the last week or two of life.

The average increase in length per week for the 18 controls is 11.3 mm. per week (extremes 18.6 to 5.5 mm.) while after 4,000 r the average is 5.9 mm. per week (extremes 8.6 to 5.0 mm. with one tumor growing a little for three weeks and then regressing). After 5,000 r, the average growth per week was 9.0 mm. (extremes 9.5 to 8.6 mm.). All three of these tumors (after 5,000 r), however, could be said to have grown at a rate normal for the slower growing controls throughout their growing period.

It is interesting to correlate the relationship of the latent period with the length of

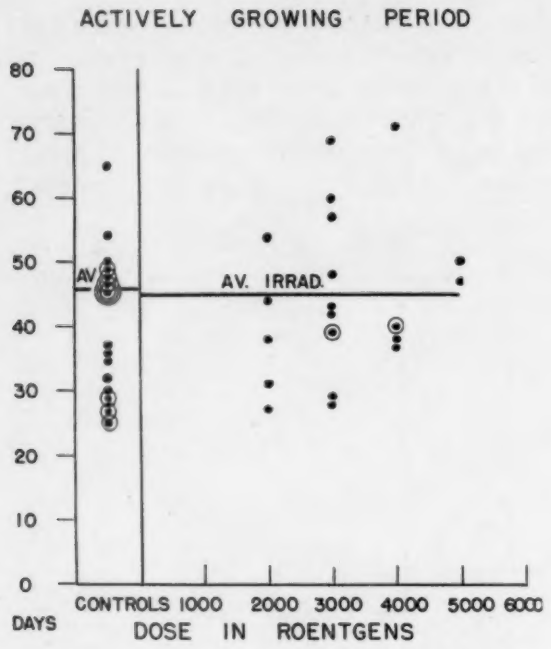

FIG. 5. The actively growing period (length of life in days minus the latent period of the tumor) plotted against the dosage of radiation (*in vitro*). This group contains only the cases where death was clearly due to tumor and contains no data on static tumors which are included in Table 1.

life. In those animals having a palpable tumor latent period within two weeks, we find that the average length of life is fifty-six days. Those animals (Methods A, B, and C) in which the tumor appeared during the third week following inoculation had an average length of life of fifty-nine days, while those in which the tumor appeared after three weeks had an average length of life of eighty-four days. It is thus readily seen that the later the tumor appeared, the longer was the length of life from the time of inoculation. It is evident in Figure 4 that the length of life increases with the dosage but the rise is parallel to the latent periods charted in Figure 2 for the same dosages. If the latent period be subtracted from the length of life (the actively growing period), the resultant figures are found to correspond quite closely to the control figures (Fig. 5). This could be used as further evidence (see also Fig. 3) of the fact that the *rate of growth of the irradiated tumors, after they are well established, varies little regardless of the dose of in vitro irradiation administered.* It is interesting to note that this figure closely approximates the figure obtained for rabbits inoculated with untreated tumors in other experiments. This would seem to indicate that *growth was almost normal in a fairly large proportion of those tumor cells which were able to survive the irradiation.* The propensity of the tumor to metastasize was not changed by the irradiation for in the group of 28 rabbits in which the irradiated tumor grew, only 4 failed to show metastatic nodules at autopsy.

The end-point (between 5,000 and 6,000 r) is approximately 7 to 8 erythema doses if the skin erythema dose for humans as used by earlier workers is considered to be about 700 r, i.e., Wood and Prime[8] for rat and mouse tumors. Despite the difference in tumors and the period at which the work was done, our results with the Brown-Pearce rabbit epithelioma correspond fairly closely with theirs. On the other hand, their work was done before reliable measurements of dosage could be made, and it is probable that the doses reported by Packard (2,700 r) and Sugiura (2,800 r) for the mouse sarcoma 180, and Lawrence, *et al*, (4,500 r) for mouse carcinoma are more representative of the sensitivity of those tumors. If such be the case, the Brown-Pearce rabbit epithelioma is much more resistant.

SUMMARY

1. The amount of radiation as a single massive dose that is required to kill the cells of the Brown-Pearce rabbit epithelioma *in vitro* or *in vivo-in vitro* is far in excess of any dose that rabbit or human skin can tolerate (over a large area).

2. As the dose is increased in steps of 1,000 r (at 200 kv.) from 2,000 to 6,000 r, the percentage of viable tumor grafts diminishes until 6,000 r is reached at which dosage no growth or takes result.

3. Those rabbits developing tumor from irradiated grafts did so at a later date than controls, the latent period being increased

as the dose of radiation received by the tumor was increased. Thus the growth rate of the irradiated tumor seems at first to be somewhat slower than the rate for untreated tumors.

4. In many cases, there is no marked difference in the growth rate of the surviving irradiated tumor tissue after the growth is measurable whether given 2,000 or 5,000 r.

5. The length of life of the rabbits from the time of inoculation of the irradiated tumor to death due to tumor is increased considerably and increases roughly in proportion to the amount of radiation administered *in vitro*. This is a result of the increased latent period.

CONCLUSIONS

1. Between 5,000 and 6,000 r at 200 kv. is required *in vitro* or *in vivo-in vitro* to prevent growth upon subsequent inoculation of the Brown-Pearce rabbit epithelioma into susceptible rabbits.

2. The rate of growth after the tumor growth is well established may, in many cases, closely approximate the rate of growth of the untreated tumor, regardless of the *in vitro* radiation dosage.

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ROENTGEN RAYS IN THE DIAGNOSIS AND TREATMENT OF TUMORS OF THE BLADDER*

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I HAVE published a number of papers upon this general subject. I have become more and more enthusiastic as to the value of roentgen rays in the diagnosis and in the treatment of tumors of the bladder, especially when they are inoperable. Since about 75 per cent involve the ureters or urethral orifice, it is self-evident that this method of treatment should be considered in a very large number of cases. I am convinced that this method of diagnosis and treatment is not utilized universally nor sufficiently for the good of such patients. Therefore, I take the liberty of presenting this matter before this Congress of distinguished radiologists with the hope that I am imparting to all of you some of my enthusiasm, and thus lead to a more world-wide use of this method.

When a patient passes bloody urine, or when there is unexplained frequency, pain or difficulty in urination, one must think of the possibility of a bladder tumor; hematuria is always a serious symptom and it is our duty to find the cause in all instances. The roentgenologist can be helpful in diagnosis no matter what is the cause, but particularly will he find pneumocystograms of value in the demonstration or elimination of a tumor of the bladder. The presence or absence of a small tumor, however, is, in my opinion, more accurately determined by cystoscopy than by pneumocystography. However, I have succeeded in demonstrating lesions less than a half centimeter in diameter. The cooperation of the radiologist with the cystoscopist is essential for the best results.

Cystoscopy and pneumocystography each is useful by itself, and generally a diagnosis can be made by either method alone, but one can obtain information by means of pneumocystograms that cannot be obtained by cystoscopy. I have been using pneumocystography since 1908, and so far as I know, I have been the first to use it in the diagnosis of tumors. This method has been discussed by me in various roentgenological meetings since that date. A formal presentation was made together with a lantern slide demonstration of a number of tumors of the bladder before the Philadelphia Roentgen Ray Society on May 5, 1919.

Tumors of the bladder can be demonstrated at times by injecting opaque material into the bladder, but personally I have found this of relatively little value as compared with pneumocystograms, because the opaque material is apt to cover up the tumor or part of the tumor. If, however, one fills the bladder with air and then rotates the patient in various positions, so that the solid tumor tissue is projected into the air space, it can be clearly shown and much detail concerning its size, position and structure can be determined. I have demonstrated tumors as small as a half centimeter in diameter, and others as large as a fist. The pneumocystogram furnishes the best photographic record of tumors so that the size, form and position of the tumor can be compared with subsequent studies in order to determine whether the tumor is disappearing under roentgen treatment.

Pneumocystograms in the study of bladder tumors have another very great advantage over cystoscopy in that they show the degree of infiltration of the bladder wall. The demonstration of the induration is possible because the part of the bladder which is normal will distend smoothly and evenly. The part of the bladder which is in-

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filtrated does not distend, and therefore produces an indentation in the general spherical outline, so that the diseased portion of the bladder is found located much nearer to the median line, The healthy portion of the bladder distends normally toward the outer wall of the pelvis. A tumor which has infiltrated the bladder wall will prevent distention of such portion. A papillary growth, on the other hand, that has not infiltrated the bladder wall will not interfere with the distention of the bladder, and one may find in connection with such non-infiltrating tumors that the bladder wall distends normally in each direction. In such cases, the bladder wall may be spherical. To determine that the bladder wall is spherical, it is necessary to examine the patient in at least four different positions.

It is a well known fact that if a tumor of the bladder has not infiltrated the bladder wall and also the surrounding tissues, the prognosis is much better than when dealing with the infiltrative type. The papillary type of cancer is more responsive to irradiation than the infiltrating variety and more rapid therapeutic results are obtained. Furthermore, the study of a bladder tumor by pneumocystograms gives the radiologist a more definite idea as to the location of the tumor and enables him to direct the roentgen rays more accurately into the base of the tumor so as to cross-fire on the diseased portion, and thereby conserve, so far as possible, the normal tissue. On the other hand, if the roentgen therapist must depend merely upon the word description given by the cystoscopist, he cannot orient the tumor so well nor can he take the greatest advantage of the cross-fire method of treatment. In some instances, there is so much bleeding from the tumor that the cystoscopist experiences difficulty in getting a clear view. Infiltration of the tumor tissue outside of the bladder wall can also at times be demonstrated.

METHOD OF EXAMINATION

Briefly, the examination of the bladder by pneumocystography requires the following:

1. Placement of the patient in the supine posture upon the Potter-Bucky diaphragm and preliminary arrangement of the tube and compression band as for an examination of the bladder.

2. Careful antiseptic cleansing of the urethra.

3. The introduction of a sterile, well-lubricated soft rubber catheter of the largest size that the urethra will take.

4. The drainage of any retained urine. Note the quantity and character of this urine.

5. Passage of a rectal tube to remove any retained gas in the rectum, and then removal of the rectal tube.

6. With an atomizer bulb attached to a properly fitting glass tube, inject air gently into the bladder until the patient complains of desire to urinate or until percussion indicates that the bladder is distended.

7. Fill the bladder and allow the air to escape two or three times. This will commonly remove some additional residual urine. It is desirable to eliminate all possible residual urine, which may diffuse or obliterate the shadow of the tumor.

8. Clamp the soft rubber catheter with a pair of hemostatic forceps and attach these forceps with adhesive plaster to the thigh so that the catheter will not come out and the air will not be expelled.

9. With the central beam of roentgen rays directed downward and forward and with the patient in the supine posture, take three or four 8″×10″ roentgenograms.

10. Hold the catheter in place while the patient turns to the prone position on the Potter-Bucky diaphragm most cautiously so as not to have the catheter and the air expelled.

11. Make three or four 8″×10″ roentgenograms with some variation of exposure value, with the central beam of rays directed obliquely upward so as to project the neck of the bladder clear of the pubic bone. A film made in the prone position

usually shows the tumor best because most tumors involve the posterior or lateral wall of the bladder, and therefore, in this prone position, the tumor will be suspended from the posterior wall in the surrounding air. Only about 14 per cent occupy the vault and anterior wall. Therefore about 86 per cent will be shown best by the examination in the prone position.

INTERPRETATION OF PNEUMOCYSTOGRAMS

Since the great majority of tumors occupy the posterior or lateral walls they will usually be best demonstrated in the films made with the patient lying prone upon the Potter-Bucky diaphragm, for in this manner the air will surround the solid tumors. One can usually get additional information, especially with regard to infiltration, in the oblique views made with the patient lying in the right and left oblique prone position. The portion of the tumor which projects into the area containing air is easily demonstrated. If there is infiltration of the bladder wall, then that portion of the bladder wall will not expand, and it will therefore be projected on the plate at a point nearer to the median line. This is most valuable evidence as to the involvement of the deeper tissues by the tumor. One can also at times recognize the solid tissue which has infiltrated outside of the bladder wall. When such conditions are present, the prognosis is distinctly less favorable. Not infrequently one can recognize small papillomata which have all the appearances of benign lesions in association with the larger carcinomatous lesion. One must be especially cautious with regard to retained fluid in the bladder, for if these

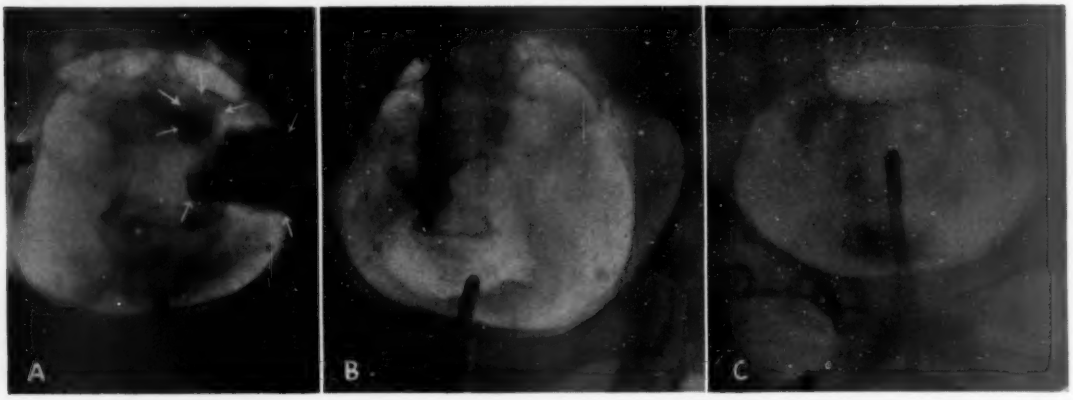


FIG. 1. Case 1. Male, aged fifty-two, referred by Dr. F. J. Dever, treated three years previously by irradiation for epithelioma of the glans penis. *A*, anterior view shows a carcinoma on left side of the bladder, and a small globular papilloma on the left wall of the bladder and a small globular papilloma above, June 8, 1928; *B*, posterior view made on the same day shows obliteration of the tumors by 8 ounces of urine. The air is above the tumor in the supine posture; *C*, anterior view, May 17, 1929, shows normal bladder wall. Patient has remained well to date, over eight years.

12. Rotate the patient in the oblique prone position, first on one side and then on the other, and pass the central ray through the median line of the bladder, making one 8″×10″ film in each position.

13. Rotate the patient cautiously to the back, remove the clamp, allow the air to be expelled, and withdraw the catheter.

14. The patient can then leave the table and either undergo roentgen treatment or go home. In only one case out of several hundred has there been any chill or any other unpleasant symptom following these examinations. It is well known that such effects may follow the passage of a soft rubber catheter for any purpose whatever, and therefore such a very rare experience should give us no special concern. There is no real danger of embolism following this procedure if the technique is carefully carried out.

soft tissue tumors are surrounded by fluid, they cannot be demonstrated.

SELECTION OF CASES FOR ROENTGEN THERAPY

In the treatment of malignant disease anywhere, one should choose the treatment that will give the best curative results with the least risk to the life of the patient, and with the least discomfort or inconvenience. In the treatment of carcinoma of the bladder, excision or destruction will probably remain the first choice for those cases discovered in an early stage when the tumor can be completely excised or can be completely destroyed intravesically, or when such destruction can be associated with the implantation of radium seeds into the base, without damage to the urethra or ureters.

In the discussion of this subject before the Pan-American Congress in 1934, Dr. James K. Young stated that 75 per cent of cancers of the bladder are inoperable when the patients come to see him. O'Crowley* says, "In view of that fact that those tumors in the lateral wall usually involve the ureteral orifices, it can be seen that these tumors located in this region with those on the trigone and bladder neck constitute 76.6 per cent. This therefore brings out clearly the fact that in only 23.4 per cent of tumors is it possible to apply complete excision without interfering with the ureter or urethra." O'Crowley has analyzed the location of 854 tumors reported to the bladder Tumor Registry involving adjacent multiple areas as follows: trigone, 32.2 per cent; lateral walls, 35.3 per cent; neck, 9 per cent; posterior wall, 10.2 per cent; vault, 7.5 per cent, and anterior wall, 5.7 per cent. In addition to this, he states that 75 per cent of 36 tumors which involved only the vault were graded 3 and 4 (Broders) and led to frequent metastases. Therefore, even the tumors involving the vault are probably best treated by irradiation. In this general analysis of

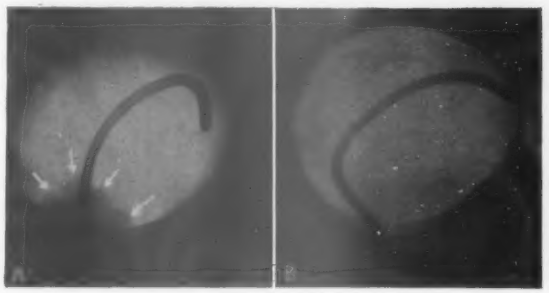
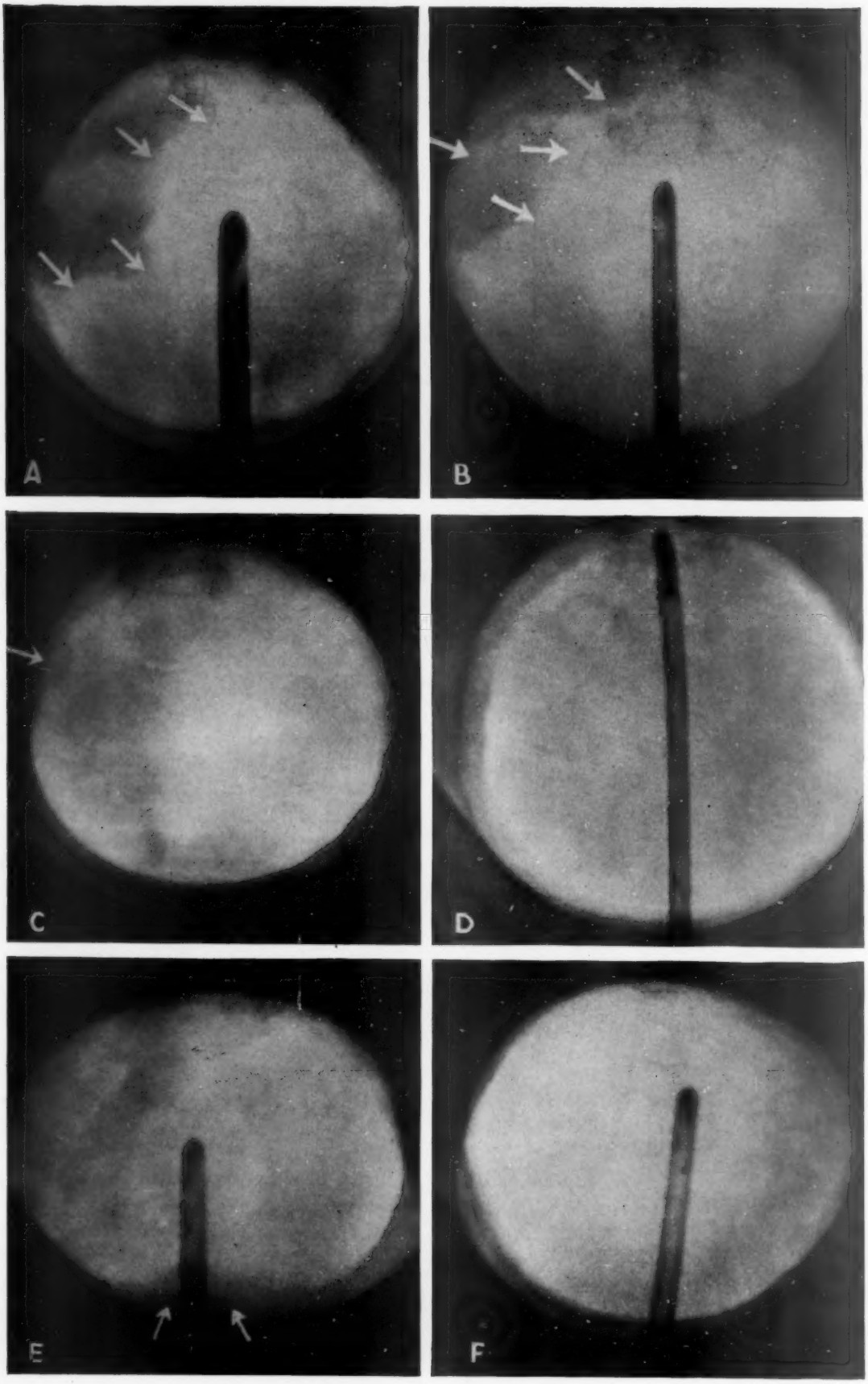


Fig. 2. Case 11. Female, aged fifty-five, referred by Professor J. M. Anders. *A*, tumor surrounding urethra June 13, 1930, posterior view; *B*, shows normal bladder January 16, 1931, posterior view. Patient has remained well to date, approximately seven years.

the bladder tumors, he found that recurrence followed the initial surgical treatment in 46.2 per cent. Of 2,597 proved cases of papillary carcinoma operated upon, 66 per cent were dead in three years. He further states, "The total estimated mortality on all cases treated by scalpel was 85 per cent. The complete cystectomy operative mortality has averaged 27 per cent." It is my opinion that any method of treatment that will cure a patient should be used, and that the particular method of treatment should be chosen which will give the least risk to the patient, the least damage to his tissues, and the least interference with his work or body functions. In the 23.4 per cent of tumors, therefore, there is naturally debatable grounds as to the best method, but in the other 76.6 per cent, deep roentgen treatment given externally will probably meet the above demands more completely than anything else that is known.

Simple benign tumors are being destroyed daily by urologists with electrocoagulation under cystoscopic guidance, but it is also well known that these tumors commonly recur after such treatment. Dr. Albert E. Bothe and I have had some favorable experience with preliminary and postoperative irradiation in preventing these recurrences. All of the malignant cases that have been referred to me for roentgen therapy were in the inoperable class, and therefore any relief or any tem-

* O'Crowley, C. R. Carcinoma of the bladder. *Ann. Surg.*, 1935, *101*, 1407–1411.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porary or permanent recovery represents just that much gain. It would seem, however, that until our roentgen technique is fully developed it is advisable to confine this heavy roentgen therapy to the inoperable group, because there is some risk of tissue damage involved also with this irradiation. In order to destroy an extensve or advanced carcinoma, it is often necessary to use a quantity of irradiation which will endanger the tissues of the abdominal wall, and perhaps injure the neighboring bowel. When extensive treatment is necessary, the bladder wall may be changed to a fibrous mass. One can minimize this damage somewhat by careful cross-firing technique, and by the use of high voltage and heavy filtration. There still remains a definite risk. I have seen constriction of the bowel develop as well as late degeneration of the abdominal wall. The type of case which responds best is the relatively early, rapidly growing papillary carcinoma. The infiltrating type requires much more irradiation and when one has a patient nearly cured, there is a great temptation to carry on the treatment even though some risk is involved.

Technique. Having determined the size, location and nature of the carcinoma by means of pneumocystograms, it should be the aim of the radiologist to cross-fire upon this disease as much as possible, and at the same time to avoid damage to normal structures. The colon or sigmoid is in most danger, because it is impossible to cross-fire upon the bladder without at the same time cross-firing upon the bowel. In dealing with large and definitely malignant tumors, no rule or definite plan of treatment can be laid down at the present time. Each patient must be treated according to the individual conditions present, keeping in

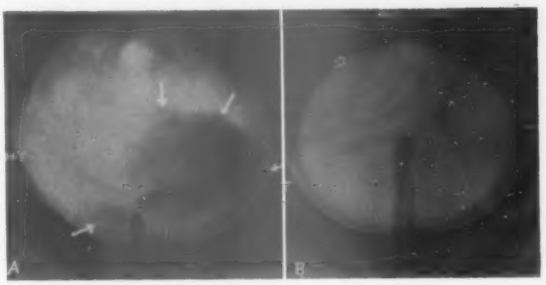

Fig. 4. Case iv. Male, aged sixty-five, referred by Dr. Ralph Getelman. *A*, two papillary carcinomas shown in anterior view, April 9, 1934; *B*, anterior view, September 30, 1935, shows normal bladder wall. Patient well to date, May 4, 1937.

mind general principles and the general condition of the patient. Therefore, it is not merely a problem of physics. Such a plan of treatment can probably be best and most practically made if there is a conference with the family physician, the urologist and radiologist, for all three of these physicians need to cooperate in order to obtain the best results in the greatest number of cases. The principles involved are:

1. We must aim to deliver enough radiation into the tumor tissue to destroy the cancer cells. This will require from 3,000 to 4,000 roentgens delivered into the tumor area. There is risk of damage when this amount is exceeded.

2. This result must be accomplished without serious or permanent damage to the patient's normal tissues. We therefore plan to give treatment to the patient through as many portals of entry (four to seven) as is possible which will permit accurate cross-firing on the disease, and by delivering 200 to 250 r daily, or 150 r twice daily, we will do less damage to the overlying tissues, and will accomplish probably the best results. We utilize for this purpose 200 kv. constant potential, 2

Fig. 3. Case iii. Male, aged fifty-four, referred by Dr. William Mackinney. *A*, posterior view shows infiltrating carcinoma on the left lateral wall with infiltration outside of the bladder, May 8, 1933; *B*, shows only moderate reduction after four months; *C*, shows almost complete disappearance after eight months. Remnant destroyed by electrocoagulation; *D*, May 24, 1934, shows bladder wall normal; *E*, May 25, 1935, anterior view, shows no recurrence but new papillomata at the urethral sphincter; *F*, May 25, 1935, posterior view does not show these papillomata.

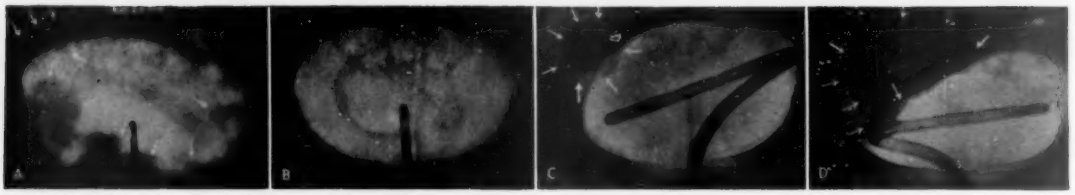

FIG. 5. Case v. Female, aged sixty-three, referred by Dr. William Mackinney. *A*, posterior view, May 26, 1934, shows carcinoma involving three-fourths of the bladder wall, with infiltration of the tumor outside of the bladder wall toward the upper left. This tumor tissue had disappeared under treatment in six weeks; *B*, September 12, 1934, posterior view shows a normal bladder wall and absence of any intravesical tumor. An abnormal density is shown above and to the left of the bladder just below the left sacroiliac joint; *C*, December 12, 1935, posterior view shows incomplete distention of the bladder upward and to the left, and shows infiltrating tumor outside of the bladder wall; *D*, posterior view on May 28, 1936, shows extensive infiltrating metastatic tumor crowding the bladder wall downward from the upper left border. The outline of the tumor tissue is indicated by arrows.

mm. copper filtration or its equivalent in Thoraeus filter, usually at a distance of 50 cm., making use either of 2 or 4 ma. of current, so as to prolong the irradiation effect as much as possible. Ferguson* and his associates began this work in 1932, and have been using 100 cm. distance, with four portals, giving 100 r through each of two opposing portals each day. Theoretically this technique is better but it does increase the time and expense. Considerable skill is necessary in directing this beam of rays toward the disease.

3. The treatment must be given in a manner consistent with the patient's general condition. Radiation sickness does not often occur in these cases, but the patient may be anemic from loss of blood, or from the effects of the carcinoma and even the radiation treatment becomes exhausting. We therefore ask for a careful blood study in the beginning, and this is repeated from time to time. Sufficient tonics and medication are given to keep the patient in as healthy and comfortable condition as is possible.

4. It should be our aim to direct the radiation to the tumor and any adjacent likely extension. I have failed in 2 cases, as I will demonstrate to you, because I did not reach the outlying disease.

5. Repeated examinations by cystoscopy or pneumocystography must be made to determine what has been accomplished, and then supplement the treatment when necessary so as to eliminate all of the disease. The most active treatment is given during a period of about four weeks. The subsequent treatment is given at intervals according to indications, but in several cases the treatment has been carried on at intervals during a period of six months.

I am hoping that some adjuvant treatment may be found which will permit a reduction in the total amount of radiation. When a carcinoma of the bladder reaches a stationary stage and yet has not completely disappeared under irradiation, it has seemed to me advisable to call upon the cystoscopist to destroy the remnant under the guidance of the cystoscope (Case III, Fig. 3). This seems to render the tumor more radiosensitive again. To obtain this result, however, it is necessary to give the radiation treatment rather promptly after the destruction. Dr. Wm. Mackinney and I have utilized this even in the destruction of benign lesions in the neighborhood of the urethral sphincter (Case III, Fig. 3), aiming to destroy only the apices of the papillomata and using the destruction merely with the object of making the tumors radiosensitive. This thought I believe is new and has not been tried sufficiently to make a positive statement.

Generally speaking, these patients are able to come to the office for their treat-

* Ferguson, R. S. Treatment of cancer of the bladder by divided doses of roentgen rays at long distances. AM. J. ROENTGENOL. & RAD. THERAPY, 1936, *36*, 73–78.

ments and their usual occupation is only interfered with by the time involved in the actual treatment. If patients have lost much blood by hemorrhage or are very anemic, they must of course conserve their energies in every way possible, and should therefore be kept at rest. Patients whose general health is good to start with usually do better. I have treated two physicians who had each a large practice, and who continued their practice during their entire treatment.

RESULTS OF ROENTGEN THERAPY IN CARCINOMA OF THE BLADDER

Fourteen cases of primary inoperable carcinoma of the bladder have been treated by me with my present technique between June 8, 1928, and June, 1935. Of these 14 cases, 7 have been free from any demonstrable carcinoma from two to nine years, or a recovery of 50 per cent. Eight cases have been treated since that date. I realize that this number is too small to permit conclusions to be drawn. Ferguson and his associates have reported 48 cases treated by distant external irradiation between May, 1932, and September, 1935. Of these he was able to study 36 afterwards cystoscopically, in which 20 showed complete disappearance of the tumors, giving 41.6 per cent of all cases treated during approximately three and a half years, and 55.5 per cent of all cases. Our results, therefore compare very well. It is a great satisfaction to find that these urologists are also convinced of the value of this form of treatment.

In my successful cases, the smallest estimated tumor dose was 2,450 r. (The disease was extremely advanced and only palliation was expected. The largest tumor dose in my failures was 9,700 r. The patient was apparently well during six months.) The bleeding usually stops in from three to four weeks. The bladder generally becomes more irritable under treatment and frequency is increased. Pain in the successful cases is usually relieved in from one to three weeks. The tumor may show a marked reduction within six weeks and total disappearance within three months. The more resistant types may show no reduction in three months and yet may disappear completely within six months.

In the unsuccessful cases, one may obtain partial or complete freedom of all symptoms lasting several months and then hematuria, frequency and pain may recur, and failure may result. All in all, with our present technique, we may expect some improvement in nearly all these inoperable cases and probably a permanent recovery in 35 per cent.

PARATHYROIDISM

EFFECT OF IRRADIATION OF THE NECK ON THE REPAIR OF BONE LESIONS*

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THE etiologic relationship between hyperfunction of the parathyroids and generalized osteitis fibrosa cystica has been established within the last ten years. This has been accomplished by the experimental production of the disease in animals by the injection of parathormone, the recovery of patients suffering from multiple cystic bone lesions after parathyroidectomy, and the frequent association of the characteristic bone lesions with pathologic fractures, hypercalcemia, hypophosphatemia and parathyroid tumors or hyperplasia.

Less is known regarding the effects of irradiation upon these glands and it is not certain whether irradiation depresses the activity of normal parathyroids. Walters, Anson and Ivy[18] exposed the thyroid-parathyroid areas in normal dogs to various amounts and techniques of irradiation and found a slight hyperplasia of the parathyroids, but no increase in blood calcium.

Compere[3a] obtained similar results after exposing the parathyroid glands of normal dogs and protecting the other structures of the neck by a sterile lead shield. There were no changes in the blood chemistry or in the bony skeleton during the six months following the irradiation.

In clinical practice it is well established that normal parathyroids are resistant to irradiation. Exposure of the neck for cancer of the thyroid or larynx with tremendous amounts does not cause symptoms of tetany. It is also known that normal glandular function is resistant to irradiation, but actively hyperplastic cellular tissue is more radiosensitive.

Although irradiation of the affected bones produces calcification of cysts and clinical improvement in some cases, a review of the literature discloses but few references on the effect of irradiation of the parathyroid region upon the course of generalized cystic bone disease. Careful study, including surgical explorations of the neck and anterior mediastinum and biopsy of bone in typical parathyroidism with severe bone changes forms the basis of this report. Our evidence indicates that a depression of osteoclastic activity can be accomplished by irradiating the cervical region in a patient with generalized cystic disease of bones. We found definite changes in the blood chemistry, deposition of lime salts in areas of bone destruction and clinical improvement following irradiation of the neck.

It is impossible to shield the thyroid and expose the parathyroids simultaneously, but the irradiation which the thyroid receives may be beneficial because of associated hyperfunction of this gland. In fact, it was a patient who had both conditions that led to the discovery of the value of irradiation in Merritt's[14] first report. This was a white woman, aged thirty-four, who developed signs of hyperthyroidism for which subtotal thyroidectomy was performed. One year later symptoms of hyperthyroidism recurred, and she complained of stiffness and swelling of the knee. The patient was emaciated and the basal metabolic rate was plus 35 per cent. Roentgen examination showed cyst-like areas of bone destruction in the end of the femur, but no other bone lesions were found. Three weeks after irradiation of the neck the patient's condition was improved, and subsequent treatment and roentgen studies showed almost complete return to normal. Although there were no blood chemistry

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or microscopic findings, the striking clinical result confirms the relationship, and later the patient was reported as remaining well for two years.

Hellström[7] reported hyperthyroidism and parathyroidism of ten years' duration in a woman, aged fifty-four. A giant cell tumor of the gum was curetted six years before admission. There were exophthalmos and increased basal metabolic rate. The serum calcium was elevated to 14 mg. per 100 cc. of blood, but the phosphorus was normal (3.8 and 4.0). A tumor in the parathyroid region was exposed to roentgen rays with lowering of the basal metabolic rate, disappearance of exophthalmos and clinical improvement. Widespread cystic bone lesions, considered metastases from a recurrent gum tumor, showed increased calcification four years later. The final result is not given, but the blood calcium remained unchanged following irradiation and there is a possibility this is an instance of multiple myeloma with secondary parathyroid dysfunction similar to Merritt's[13] Case II. Wagoner[17] reported a patient with parathyroidism in whom the basal metabolic rate was depressed from plus 4 to minus 24 over a period of fifteen days during which five exposures were given. No ill effects were noted and the rate rose to normal within six months.

Cutler and Owen[4] made an important contribution in suggesting radiation treatment of each parathyroid area separately as a possible aid in localizing the lesion in order to make exploration less difficult. They report the case of a white male, aged forty-three, with classical parathyroidism of over five years' duration in whom a diagnosis of Paget's disease had been made two years before they saw him. He was emaciated, unable to move his legs, and the muscles showed hypotonicity with diffuse tenderness. Roentgenograms showed extensive and severe cystic bone changes but roentgen therapy was given over the spine and long bones without improvement. The blood calcium was exceedingly high (29.4 mg. per 100 cc.), and no Bence-Jones bodies were demonstrated in the urine. Three fields over the neck and upper chest were irradiated separately and blood calcium determinations made before and after treatment of each field. After the administration of 500 r to all fields at once and then to each field separately in a period of ten to fourteen days with from nine to seventeen days between each series, the greatest drop was obtained when the left side was irradiated. No exploration was done. The bones showed increased calcification, disappearance of cystic areas and normal density. However, the last calcium determination a year after admission was still elevated (13 mg. per 100 cc.), but the patient's condition was steadily improving. The muscular strength and tonicity improved so he could walk short distances and the pains disappeared. It is still possible that an adenoma is present in this patient, although the parathyroids may have been merely overfunctioning.

Merritt and McPeak[11] reported 5 cases of cystic bone disease benefited by roentgen therapy over the parathyroid region. In a man, aged sixty (Case III) the calcium dropped from 12.6 to normal (9.03) and the phosphorus rose from 1.96 to 4.0 after ten treatments over the cervical region. The patient was clinically well ten months later and showed some healing of the cystic areas of the radius and ulna. The response was more rapid than in our case.

Similar improvement following roentgen therapy has been reported by other authors notably Weil (quoted by Mandl[10]). Huguet[9] reported a limited cystic lesion of the radius and changes in the pelvis and tibiae in a woman of sixty-six. Roentgen therapy of the parathyroids reduced the calcium content of the blood and urine to normal and the bone lesion of the radius was improved. The ultimate result is not recorded.

On the other hand, Albright[2] and his associates followed the total calcium and phosphorus metabolism of a patient (Case IV) who received maximum (exact amount not stated) roentgen exposures over the neck without detecting any change in the

FIG. 1. *A*, admission film of right femur showing pathologic fracture, decalcification, and cystic lesions. *B*, left femur on admission with similar extensive bone changes. Observe lack of contrast between soft tissue and bone.

urinary excretions or blood values, and subsequently a parathyroid tumor with no degenerative changes was removed. Another patient (Case VI) also received roentgen treatment without relief.

In 1931 Quick and Hunsberger[16] reported the results of roentgen treatment of a palpable parathyroid tumor in a patient suffering from generalized cystic disease of bones (amount of treatment not given). They stated that, following the removal of a parathyroid tumor, the serum calcium again increased and roentgen therapy was given without improvement.

Dresser[5] reported a patient (Case II) very similar to ours who had removal of two lower normal parathyroids and later received high voltage roentgen therapy to the neck (amount not stated). Although there was some deposition of calcium in the bones and symptomatic improvement, there was progressive impairment of renal function and a second surgical exploration of the neck was contemplated. Another patient (Case III) received 700 r to the neck without any appreciable change in her condition at the end of the series of treatments.

Gutman[6] and his associates reported an autopsied case (Case IV) with parathyroidism and two tumors, who received roentgen therapy (amount not stated) over the neck but there was apparently no response for the disease progressed steadily.

Churchill and Cope[3] stated that their patient (Case VII) received high voltage roentgen therapy (amount and area not given) without improvement, and, after a second operation, an adenoma was found beneath the sternum. Tetany followed the operation, but the patient made a satisfactory recovery and was improved. We felt that we might be dealing with a similar situation, but no tumor could be found.

The report of our case is as follows:

Mrs. M. W., aged thirty-seven, a colored cook, was admitted to the Western Pennsylvania Hospital on October 19, 1936, complaining of pain in the back and both thighs and inability to walk.

The present illness began five years previously following the birth of the sixth child. There was weakness and pain in the back and left thigh. This became progressively worse until she was finally bedfast. During the seventh pregnancy, in August, 1935, she had increasing difficulty in walking and fell several times because her legs gave way under her. About this time she came to the dispensary where the reaction to the Kahn test was found to be 3 plus, and antiluetic treatment was begun. This pregnancy terminated with a stillbirth. Antiluetic treatment was continued intermittently until admission when she became so weak and had so much pain she could no longer walk. Because of muscular weakness she even gave up doing embroidery which she enjoyed.

Her past history was irrelevant except for nocturia 3 times, frequency and dysuria. The family history stated that her mother and father had "rheumatism," but there were no other chronic diseases in the family.

Physical examination showed an obese, colored female, sitting propped up in bed with

an evident fracture of the right thigh, and suffering great pain. The rest of the examination was negative except for the following findings: The upper and lower jaws were edentulous, and there was tenderness over the spine, pelvis and both thighs. The left thigh was swollen and the left lower extremity was externally rotated and abducted. The systolic blood pressure was 110, the diastolic 70. There was obvious muscular weakness.

Roentgen examination of the skeletal system was difficult because of the patient's inability to cooperate and the high degree of decalcification which allowed very little contrast with soft tissues. The right femur (Fig. 1, *A*) showed a pathologic fracture at the junction of the middle and distal thirds with inward displacement of the distal fragment. This fracture was through an area of cystic and decalcified bone destruction. The left femur (Fig. 1, *B*) presented a large area of bone destruction with the cortex intact which was the only portion of the bone remaining. In both femurs the demineralization and cyst formation extended into the knees and involved the proximal thirds

Fig. 2. *A*, right femur one and a half years after Figure 1*A* following five courses of roentgen therapy to the neck. *B*, same for left femur. Note filling in of cystic areas.

Fig. 3. *A*, calvarium upon admission showing cystic areas involving both tables. *B*, five months later following two courses of irradiation over the neck demonstrating complete recovery from former bone changes.

of both tibiae. The ribs and thoracic and lumbar vertebrae showed almost total loss of calcium with cupping of the vertebral bodies and an increase in size of the intervertebral discs. Bone striations were very poor and the bones looked like the surrounding soft tissues. There was very extensive demineralization of the pelvic girdle with large cystic areas of lessened densities in the pelvic bones and upper femora. The appearance of the skull (Fig. 3, *A*) was striking since it showed small round areas of bone destruction involving both tables with alternating patchy areas of increased density. There were small cysts of the phalanges of the right hand and the tip of the left ring finger. The roentgen findings suggested a diagnosis of multiple myeloma or parathyroidism.

The pertinent laboratory findings were as follows: The Bence-Jones protein was not

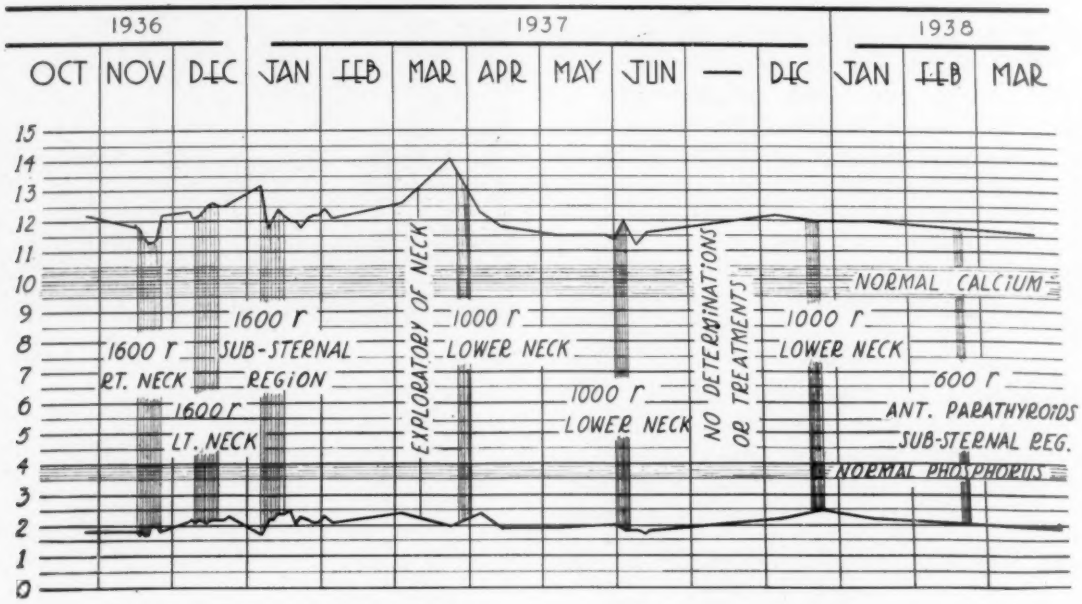
found. The Kahn test was 1 plus. The urinalysis showed 1 plus albumin, an occasional red blood cell and many white blood cells. The hemoglobin was 80 per cent, the red blood cells, 4,290,000 and the white blood cells 10,000 per cubic millimeter. The differential count was 54 per cent polymorphonuclears, 32 per cent small lymphocytes, 10 per cent large lymphocytes, and 4 per cent transitional and large mononuclear cells. The blood calcium was elevated to 12.2 mg. per 100 cc. (normal value 9.5 to 10.5 mg. per 100 cc.) and the blood phosphorus was low, 1.8 mg. per 100 cc. (normal value 3.5 to 4.0 mg. per 100 cc.). The non-protein nitrogen was 25 mg. per 100 cc. (normal value 26–40 mg. per 100 cc.). The blood sugar was normal. Two basal metabolic rate determinations were normal showing minus 1 per cent. These additional findings favored the diagnosis of parathyroidism, rather than myeloma.

Buck's extension was applied to the right lower extremity and a specimen for biopsy was taken from the fracture site of the right femur which consisted of bone cortex and medulla. The pathologic report was as follows: "Two pieces of flat compact bone with some spongy bone and adherent soft tissue, measuring respectively 3×12×15 mm. and 4×15×16 mm. There is also a mass of cancellous bone measuring about 1.5 cm. in diameter. The adherent soft tissue varies from translucent yellow to deep red. Microscopic: Section exhibits normal active bone marrow. There are, however, two foci where the marrow is replaced by granular cellular debris and collagenous material containing fibroblasts and a few pyknotic nuclei. Skeletal muscle shows marked degeneration and necrosis of nuclear infiltration. Section of bone exhibits fatty type of bone marrow throughout the greater part of the section. Only in the periphery are occasional areas of active bone marrow found. The fatty bone marrow shows extensive fibrosis of the fat, often associated with cells resembling osteoclasts, the latter lying against the ragged, moth-eaten margin of an osseous trabecula. This fibrous bone marrow contains very few cells. The bony trabeculae show areas of rarefaction and the margins often indicate bone resorption by the ragged, moth-eaten outlines. Diagnosis: Osteitis fibrosa. No evidence of neoplasm." This

TABLE I

CALCIUM AND PHOSPHORUS DETERMINATIONS

IN MILLIGRAMS PER 100 CUBIC CENTIMETERS OF BLOOD



gave absolute confirmation of the diagnosis of parathyroidism which had been provisional because of the muscular weakness, pain and severe bone changes with pathologic fracture, and the hypercalcemia and hypophosphatemia with urinary symptoms.

Since there was no evidence of a mass in the neck, we tried to localize the suspected adenoma or hyperplastic parathyroid by giving a selective therapeutic test of irradiation. We did this by applying a total of 1,600 roentgens (measured in air) in nine days, giving 200 r, with an effective wave length of 0.15Å per daily exposure, using a field 15×10 cm. in size over the right neck and thyroid region. Daily blood calcium and phosphorus readings showed an average drop of 0.5 mg. per 100 cc. in the calcium and a 0.2 mg. rise in the phosphorus (see Table 1). (The accuracy of these readings is within 1 per cent according to our biochemist.) After two weeks, during which the calcium and phosphorus remained stationary, exactly the same technique of roentgen therapy was used over the left side, but the calcium rose and the phosphorus remained the same. About two weeks later, when the calcium had reached a new high and the phosphorus was as low as it had ever been, we treated the upper anterior mediastinum with identical technique, and obtained the most pronounced changes with a drop of 1.1 mg. in the calcium and a 0.7 mg. rise in the phosphorus. The radiation reaction was moderate with sore throat, husky voice and discomfort on swallowing. Roentgen studies of the right femur showed beginning callus with less decalcification of the shaft. We were now able to obtain satisfactory roentgenograms of the spine (Fig. 4).

We therefore told the surgeon we suspected the lesion was in the lower right parathyroid area or beneath the manubrium sterni. However, two months after the last treatment with the patient under general anesthesia, a very careful search revealed no adenoma or enlarged parathyroid anywhere. There was profuse bleeding at operation which did not interfere with the procedure, and convalescence was uneventful with excellent wound healing.

Two weeks after operation the calcium rose to another high (14.1 mg.), but the phosphorus remained the same. Therefore, further radiation therapy of 1,000 r was given in five days as before except that only one larger portal 12×18 cm. covering the lower neck and upper chest was used. Her general condition continued to improve, there was a drop of 1.8 mg. in calcium and a rise of 0.4 mg. in phosphorus, and roentgen studies of the skull (Fig. 3, *B*) showed thickening of the bones with complete disappearance of the cysts which were replaced with increased density. Eight weeks later the patient could walk for the first time since admission. Another course of roentgen therapy exactly like the last was given and produced the same effects on the blood chemistry (Table 1). She was discharged on June 11, 1937.

Fig. 4. Spine after two courses of irradiation over the neck showing cupping of vertebral bodies (typical fish-bone vertebrae), and great increase in calcium content when compared with admission films.

The patient was re-admitted on December 5, 1937, giving an interval history that since discharge she had been getting along on crutches, occasionally walking without them for a short distance. The day of admission she fell in rising from her chair, landing directly against

FIG. 5. Right femur thirteen months later (at re-admission) with dense new bone formation about old fracture site and improved contrast but still somewhat cystic and decalcified. (New linear intertrochanteric fracture visible in original, without displacement.)

her right hip. Roentgen examination of the right hip showed a slight linear fracture, intertrochanteric in type. The previous fracture remained solidly healed (Fig. 5) and the decalcification was less.

Laboratory examinations at this time revealed a negative Kahn reaction, and the blood count improved as follows: The hemoglobin was 90 per cent, the red blood cells 4,470,000 and the white blood cells 7,500 per cubic millimeter. The differential count was 58 per cent polymorphonuclears, 26 per cent small lymphocytes, 6 per cent large lymphocytes, 8 per cent transitional and large mononuclear cells and 2 per cent eosinophiles. Urinalysis remained as before with 1 plus albumin and many white blood cells. The blood calcium was still high (12.2 mg.) and the phosphorus low (2.2 mg.).

The patient was put in traction and roentgen treatment over the neck similar to the last series in June (1,000 r in five days to an area 12×18 cm.) was given. The traction was removed on January 24, and she was allowed up in a wheel chair. On February 12, she was allowed to walk with crutches. Two months after the last series 600 r was given to each of two portals over the anterior neck and upper sternum in three days with the same effect on the blood chemistry. The patient was discharged walking on crutches on March 2, 1938.

A check-up examination on March 23, 1938, showed the patient to be in good condition (Fig. 6), able to assume good posture and walk

FIG. 6. Follow-up examination eighteen months after first admission demonstrating excellent state of health, and fair posture. Increased pigmentation over treated areas is well shown.

unaided. The blood calcium was still slightly elevated (11.6 mg.) and the phosphorus was low (1.9 mg.). The phosphatase was elevated to 16 Bodansky units (normal for adults 6 to 8).

Because we felt an adenoma might be present beneath the sternum the patient was readmitted on April 22, 1938, for another exploratory operation. The blood calcium was nearer normal than ever (10.8 mg. per 100 cc.), but the phosphorus was still low (1.8 mg. per 100 cc.). A small asymptomatic calculus was found in the right kidney (Fig. 7) which was not present before. Roentgen examination of the esophagus showed no evidence of a tumor pressing upon it. Under general anesthesia, after splitting the sternum in the midline and obtaining good exposure, careful search revealed no tumor or hyperplastic parathyroid tissue anywhere, and the wound was reluctantly closed. A brownish fatty mass was examined microscopically, but showed nothing abnormal.

The patient stood the operation well and made an uneventful recovery. Postoperative blood calcium and phosphorus determinations were as follows: two days after operation, calcium 11.6 and phosphorus 1.8 mg. per 100 cc. Two weeks postoperatively the calcium was 11.4 and the phosphorus was 2.2 mg. per 100 cc. There was no sharp increase in blood calcium such as followed the first operation. The patient is in good health (April, 1939), has a few muscular pains which are disappearing and embroiders again easily.

Fig. 7. Arrow points to small asymptomatic calculus in right kidney at time of mediastinal exploratory. Coarse striations are still present in the pelvic bones.

COMMENT

Our patient has received a total of 9,000 r over a period of fifteen months and the condition of the skin is satisfactory for further roentgen therapy if this is thought advisable. This may be required, but will not be given while the patient continues to improve. It appears probable that the roentgen therapy has produced an effect which is comparable with extirpation of a parathyroid tumor. That the parathyroidism has not entirely disappeared is evident because the blood chemistry, although improved, is still not normal. We seem to be dealing with hyperfunctioning parathyroids without a definite adenoma or hyperplasia, similar to the patients reported by Hitzrot and Comroe[8] and Albright *et al.*[1] However, an adenoma may still exist as in Noble's[15] patient where the tumor was found only at autopsy after surgical exploration under local anaesthesia failed to reveal it. It is also possible that the roentgen treatments caused shrinkage of the tumor or hyperplastic glands so that they could not be found at either operation. The positive serology became negative under appropriate therapy, and therefore probably had little to do with the parathyroidism.

The evidence we have indicates that, in some patients at least, roentgen therapy does produce satisfactory results. No conclusions can be drawn from a single case, but these observations are highly suggestive of the value of irradiation. Whether these results are as permanent as those following surgical treatment remains to be determined. We do not recommend radiation treatment *instead* of surgery, but if there are contraindications to surgery or if parathyroidectomy fails to produce a cure, irradiation may prove valuable.

SUMMARY

1. A typical example of parathyroid dysfunction but without demonstrable parathyroid tumor associated with advanced osteitis fibrosa generalisata is reported.

2. The value of irradiation of the neck on the repair of bone lesions and the improvement in blood chemistry and clinical symptoms in this patient are emphasized.

3. A selective therapeutic test of irradiation as described is suggested whenever possible as an aid in localizing a lesion of the parathyroids before operation.

4. The relative value of surgery or irradiation regarding permanency of results remains to be determined.

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SURGICAL AND RADIATION TREATMENT OF THE VARIOUS PHASES OF CARCINOMA OF THE BREAST*

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THE correct therapeutic planning in carcinoma of the breast, as in malignant disease generally, depends upon the diagnostic evaluation of the severity of the condition and the stage of its development.

In the course of the last decade, following microscopical investigations of Broders of the Mayo Clinic, there has developed a tendency to base the methods of treatment and the prognosis in carcinoma on the microscopical findings of tissues obtained by surgical procedures. Broders grades the severity of malignancy in accordance with the proportional relationship between differentiated and dedifferentiated carcinoma cells. In the least malignant Grade 1 tumors between 100 per cent and 74 per cent of the cells are differentiated. In Grade 2 tumors the differentiated cells range between 75 per cent and 50 per cent. In Grade 3 between 50 per cent and 25 per cent are differentiated and in Grade 4, or the most malignant tumors, only from 25 per cent to 0 per cent of the cancer cells are differentiated.

Pathologists always realized the fact that the least differentiated carcinoma cells are the most malignant. It is doubtful, however, whether an actual mathematical precision exists even under the most favorable conditions, as, for instance, in epithelioma of the skin. In carcinoma of the breast the relationship between the clinical malignancy and the microscopical structure is remote indeed.

Carcinomatous tissue of the breast in its incipiency retains so completely the structure of the part of the mammary gland from which it is derived, whether the *ducts* or the *acini*, that it is indistinguishable morphologically from the normal tissues. This resemblance, however, between the normal and malignant cell of the mammary gland is only structural or static in its character, while dynamically or physiologically the two types of cells represent two entirely different entities. Furthermore, two groups of cancer cells which appear identical morphologically may possess different degrees of malignancy. Unlike epithelioma elsewhere, in carcinoma of the breast the percentage of dedifferentiated cells may vary not only between the primary and secondary tumors but even between the adjoining regions of the primary tumor since the cells become less differentiated towards the periphery. Scirrhous carcinoma of the breast consists of much less differentiated tissue than an adenocarcinoma, but the former is a much less malignant type of tumor than the latter. The secondary metastatic tumors in scirrhous carcinoma, however, are more dedifferentiated than the original growth and are clinically more malignant even than adenocarcinoma. Thus in scirrhous carcinoma, the entire clinical picture is frequently the result of the metastatic tumors while the primary growth is undiscernible.

In view of all this, the correct evaluation of methods of treatment and of the prognosis in carcinoma of the breast must be based not on morphological but on clinical grading of malignancy. Moreover, the relative therapeutic value of surgery and radiation treatment in carcinoma of the breast and the correct correlation of these two methods depends not so much on the grade of malignancy of the primary tumor as on the rapidity of its invasive growth and on the extent and location of the secondary metastatic tumors. In order to appreciate these differences in the manifestations of malignancy in carcinoma of the breast and in primary carcinoma of other organs, it is

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important to bear in mind the meaning of malignancy in tumors generally.

The clinical course of cancer, the malignancy of a cancerous growth, is due to two characteristic features of a cancer cell, namely, its capacity of *infiltrating into and destroying the adjacent normal tissue* and of replacing it by cancer cells and the ability of the cancer cell to separate itself from the primary tumor, multiply when transplanted into a new locus and thus create secondary metastatic tumors.

The infiltrating growth of the cells of malignant tumors is the main reason for the clinical course which these tumors take and for the ultimate destruction of the organism of the host. The cancer cells use up the food of the adjacent normal cells, injure, and subsequently destroy these normal cells.

Such deterioration and ultimate destruction of normal adjacent tissue and its replacement by tumor tissue continues progressively until the wall of a main artery is destroyed and the patient dies of a hemorrhage, or a wall of an organ is destroyed, or a serous cavity is perforated and the patient dies of secondary infection, or a vital organ (liver, lungs) is destroyed.

The mechanism of the formation of metastasis in malignant tumors consists of the following phases: (1) the detachment of a group of cancer cells from the primary tumor, (2) the transportation of this group of cells into distant parts of the organism, and (3) the proliferation of these cells in the new locus and the consequent formation of secondary metastatic tumors.

The experimental as well as clinical investigations[1] which I have conducted on the mechanism of formation of metastasis in cancer indicate that tumor emboli are transported everywhere with the same ease and find lodgment in any part or organ of the body. The further growth, on the other hand, of a small transported group of cancer cells and its development into a large metastatic tumor depends upon a correct metabolic affinity between the cancer cells, on one hand, and the organ cells, the soil as it were, on the other. A metastatic tumor forms only when the transported cancer cells succeed in overcoming the inhibiting powers of the normal tissues of the new locus. Malignant tumors derived from different organs and tissues show great variations in the frequency and rapidity of the formation of metastases.

The following two instances show clearly these variations in the modes of malignancy and consequent variations in the clinical course. Cancer of the cervix involves the surrounding normal tissues (rectum, urinary bladder, uterus and blood vessels) and regional lymph nodes. Rarely are metastases formed in distant regions and then only late in the course of the disease. In carcinoma of the breast, metastases in distant regions (distant lymph nodes, lungs, liver, skeleton) appear frequently and usually early in the course of the disease.

This ease and readiness with which distant metastases are formed in cancer of the breast must be taken into consideration in the selection of the therapeutic procedures for the various phases of the disease. This choice becomes even more difficult since two cases of cancer of the breast in the same stage of development may differ in their clinical course, showing greater or lesser rapidity of the local growth and great variations in the frequency of occurrence of distant metastases. A scirrhous carcinoma of the breast may remain localized for years without disturbing the rest of the organism, while a medullary carcinoma may kill the patient in a few months or even weeks. In some cases the carcinoma of the breast which appears to be in a comparatively early stage will recur locally soon after a most extensive operation, while throughout the whole subsequent course of the disease no distant metastases will be noted anywhere. In other cases, the result of the operation will be apparently perfect, there will be no local recurrence and yet, as late as twenty years after the operation, a metastasis will occur in the head of a femur or in the pelvic bones.

Early formation of metastases, however, remains true for the major number of cases of carcinoma of the breast. The metastatic tumors begin in the axillary lymph nodes and then develop and spread very rapidly to other regions. In reality, the moment the condition ceases to be precancerous, minute metastatic tumors may already be present in distant organs.

In view of this clinical behavior of carcinoma of the breast, surgical removal of the tumors, whenever technically possible, remains the method of choice since surgery acts promptly in removing the whole tumor and thus stops immediately the metastatic transportation of tumor tissue, while radiation treatment acts slowly and leaves ample time for such transports.

On the other hand, the type of surgery to be employed as well as its correct coordination with radiation treatment depends upon the phase of the development of the carcinoma of the breast found upon examination.

As stated above, from the standpoint of therapeutic methods to be applied and the therapeutic results to be obtained, the local invasive spreading of the primary tumor and, what is more important, the location of the metastatic tumors must be taken into consideration. From this viewpoint all cases of carcinoma of the breast as they present themselves for treatment may be divided into the following nine phases each of which requires a different therapeutic approach: *Phase 1* embraces the cases in which there is no evidence of invasion of surrounding tissues or metastases anywhere; *Phase 2* represents cases with metastases found only in the axillary lymph nodes; *Phase 3* represents cases in which metastases are found not only in the axillary but also in the supra- and infraclavicular lymph nodes; *Phase 4* represents cases in which the primary tumor is ulcerated but movable over the chest wall; *Phase 5* represents cases in which the tumor is attached to the chest wall; *Phase 6* represents cases of local recurrence after a radical mastectomy; *Phase 7* represents cases with metastases in the lungs; *Phase 8* represents cases with metastases in the skeleton; *Phase 9* represents cases with metastases in the liver and with generalized carcinomatosis.

Each of these phases, as mentioned previously, requires a different therapeutic technique and will therefore be discussed separately.

PHASE 1: NO INVASION NOR METASTASES

In this early phase of the disease, the diagnosis and consequently the correct treatment may offer great difficulties. An encapsulated tumor freely movable within an otherwise normal breast in a young person is most usually a benign adenofibroma or cystadenoma and may require only local excision. However, some of these benign tumors may undergo malignant degeneration and, furthermore, cases of true carcinoma of the breast have been observed by other clinicians and myself in girls of sixteen years of age and younger. Every benign tumor must therefore be subjected to microscopical analysis and if malignancy is found a radical mastectomy must follow.

If a solitary tumor found in an otherwise normal breast is hard and nodular in consistency and passes diffusely into the surrounding tissue, the diagnosis of malignancy offers no difficulties. The problem becomes very complicated and difficult when a carcinoma develops within a breast which is in a state of chronic cystic mastitis, and this is particularly difficult when, as is usually the case, both breasts are involved in the process. Neither transillumination nor roentgen examination will show any difference between the part of the masses of the breast in the state of chronic mastitis which has undergone malignant degeneration and the benign mass. Palpation, however, will show that the malignant area is harder in consistency and more finely nodular. When such a change is found in chronic cystic mastitis, it is impossible to expect a correct diagnosis from a trocar or aspiration biopsy. The correct procedure is to do a wide excision of the tumor surrounded by normal adjoining

tissue, cut through the excised tumor and if the tumor appears malignant on gross inspection then a radical mastectomy should follow immediately. If the diagnosis cannot be established on gross inspection, then a frozen section for microscopical examination should be made of the tumor while the patient is in the operating room and if malignancy is found a radical mastectomy should follow. It must be borne in mind that even with all these precautions a small area of malignancy may be overlooked and therefore the patient who had only a local excision should be watched carefully for a long time.

The following 3 cases illustrate the difficulties encountered in establishing the diagnosis of malignancy within chronic cystic mastitis and the very malignant course which the condition may take.

CASE I. A. B., female, aged forty-one, was seen in April, 1924. On examination both breasts were lumpy but in the left breast one diffuse mass was harder than the rest and nodular. This mass was excised in the manner described above and frozen sections prepared. Three slides showed pictures of chronic cystic mastitis but the fourth slide showed an area of carcinoma surrounded by chronic cystic mastitis. A radical mastectomy was done. Subsequent analysis showed that a small lymph node in the axilla which could not be palpated before the operation contained metastatic carcinoma.

CASE II. L. D., female, aged fifty, was seen in April, 1926, giving the following history. In June, 1921, she noticed a lump in the right breast. A local excision of the tumor was done and no malignancy was found. In October, 1923, a recurrence of the tumor was noted. Again only a local excision was done, malignancy found and the operation followed by some roentgen and radium treatment. On examination a diffuse hard and nodular mass was noted in the lower inner quadrant of the breast, measuring about 2 cm. in diameter and adherent to the scar but freely movable over the chest wall. No lymph nodes were palpable in the axilla or supraclavicular region. The left breast appeared normal. The patient was advised to undergo a preoperative course of radiotherapy to be followed by a mastectomy, but refused treatment. She reappeared six years later. At this time the tumor in the right breast was found much larger, a tumor was palpated in the right axilla and also in the left breast. A double radical mastectomy was done and radiation treatment given. The patient died three years later from metastases in the lungs.

There was no local recurrence or metastasis in the skin of the chest, thus showing that the surgical results were perfect.

CASE III. A. W., female, aged forty-nine, was seen in October, 1932. On examination there was found in the left breast a tumor mass about 4 cm. above the nipple, irregularly round in outline and measuring about 4 cm.in diameter. On palpation this tumor mass appeared in some areas firm and elastic and in others hard and nodular. In the left axilla a very small firm lymph node was palpated, about the size of a buckshot. A diagnosis was made of chronic cystic mastitis with malignant degeneration in some areas. A radical mastectomy was done. Microscopical analysis of the primary tumor showed chronic cystic mastitis with a great deal of fibrosis and occasional small islands of carcinoma cells. The small lymph node showed a metastatic nodule of solid carcinoma. Clinical and roentgen analysis showed no evidence of any distant metastases.

Notwithstanding the very mild nature of the primary tumor the patient died two and a half years later from metastases in the lungs, though she received an extensive course of radiation treatment.

When the malignant nature of a tumor of the breast is demonstrated and when a clinical and roentgen analysis shows no evidence of any metastases and the case consequently belongs to Phase 1, then surgical treatment must be proceeded with immediately to obviate metastatic transport of cancer cells.

In the course of the last thirty years much progress has been achieved in the surgical treatment of cancer. The so-called radical methods of operative procedure were developed as a result of anatomical studies of the distribution of the lymph channels through which the disease spreads.

An excellent example of such studies is the anatomical and pathological investi-

gations of Handley[2] on cancer of the breast. He has shown that groups of cancer cells from the primary tumors in the breast permeate into the lymphatic vessels of the deep fascias of the chest wall. Subcutaneous nodules of recurrence arise only subsequently from the permeated fascial lymphatics along its tributaries. As a result of his investigations, Handley proposed certain improvements in the methods of the surgical amputation of the breast for carcinoma as previously elaborated by Halsted and Willy Meyer. Handley considered the following to be the object in surgical removal of the breast for carcinoma: "The removal intact of the permeated area of the lymph vascular system which surrounds the primary growth and of the lymph nodes which may have been embolically invaded along the trunk lymphatics of the area concerned." Thus modern surgery strives to remove all the normal tissues adjacent to the malignant tumor and into which the latter spreads most frequently and also to remove all regional lymph nodes. By the aid of these methods very remarkable results may be obtained in the so-called operable cases.

Electric Surgery. About twenty-five years ago it was definitely established that the physiological effect of high frequency currents on the organism is the production of Joule's heat, i.e., heat which is developed throughout the tissues located between the two electrodes. Immediately after this discovery high frequency (*diathermie*) currents began to be employed for the surgical destruction of malignant tumors *in situ*.

The following physical phenomenon makes such a destruction possible. The intensity of the heat which develops under the influence of the same current in the tissues between the two electrodes is in inverse ratio to the size of the electrodes. When the electrodes are very small, the tissue is heated to such a degree that it undergoes a state of coagulation necrosis. This method of heat destruction of tissue is called electrothermic or diathermic coagulation.

The surgical coagulation of tumor tissue may be accomplished in two ways. Either two small active electrodes of the same size are placed over two opposite ends of the tumor, and then the coagulation takes place in the part of the tumor located between the two electrodes, or when the tumor is situated in the mouth or another cavity, then the two electrodes cannot be applied and another method has to be employed. This method consists in applying one large neutral electrode over the back, abdomen or some other part of the body of the patient and another small active electrode over the part of the tumor to be coagulated. By this method the coagulation takes place in the tissues next to the active electrode, while the tissues in the area of the large electrode are only heated to a slight degree. This method is simple technically, but the depth of coagulation cannot be controlled. To obviate these difficulties I devised[3] a double active electrode placed in one handle with a double cord. The electrodes are built in a straight or curved line with flat or sharp points. With this electrode, it is possible to enter with ease into the oral or other cavities and to do the coagulation without injuring the adjacent tissues.

When a diathermy machine is used with a large neutral electrode and a needle point for an active electrode, the latter acts like an electroknife. This knife may be superior to an ordinary scalpel when the excision is close to the tumor, since it coagulates a thin layer of tissue besides cutting it and thus closes up the lymph and blood channels. As a result, there is less chance of bleeding as well as of dissemination of minute particles of tumor tissue.

I consider electric surgery an important addition to surgery in malignancy generally, but in carcinoma of the breast I make comparatively less use of it. Diathermic coagulation, I use only occasionally, in Phase 4 when there is a great deal of redundant tissue present and the electroknife occasionally in removal of local recurrence. The incision in mastectomy

whether radical or palliative must be made within normal tissue at a good distance from the tumor, and therefore the electro-knife is not indicated in this operation.

Radical mastectomy was the earliest and the most brilliant achievement of the whole field of cancer surgery and seemed to give excellent immediate results. This is evidently the reason why some surgeons, even today, maintain that surgery alone is the only treatment of value in carcinoma of the breast. In reality, however, the ultimate results of surgery in carcinoma of the breast are such that the need for additional methods of treatment is unquestioned.

In 1929, a committee[4] of the American College of Surgeons reported on the treatment of carcinoma of the breast. The committee has tabulated statistically 774 cases. This statistical investigation revealed the following results of surgical treatment unsupported by irradiation. Of the 774 cases studied, 15 per cent showed no glandular involvement, and of these patients 57 per cent, i.e., 8 per cent of the whole number of 774 patients, remained well for five years. Involvement of the axillary lymph nodes was present in 35 per cent, and of these only 16 per cent, or 5 per cent of the whole number of patients, remained well for five years after a radical operation. Thus 13 per cent of these cases of carcinoma of the breast remained well for five years. One must keep in mind the further fact that many in this 13 per cent will have developed local recurrences and more often metastases in distant organs after the five year period.

This small percentage of cases which are cured by surgery alone proves that, while therapy of carcinoma of the breast remains a surgical domain, the orientation of the surgeon as regards the position which surgery occupies in the therapeutic armamentarium must change. On one hand, as will be shown later, surgery is indicated today much more frequently than in the period before the discovery of radiation. On the other hand, surgery should never be considered the only or the most important method of treatment, but rather a very important and indispensable adjuvant to irradiation.

For the future progress of therapy in carcinoma of the breast, it may be well to discontinue the terms "radical" and "palliative" surgery. The borderline between these two types of surgery cannot be well defined and the ultimate result is never certain. On the other hand, much may be accomplished for the individual cancer patient if less thought is given to clinical statistics and more to the special needs of the individual case and to the special requirements of the irradiation in the case.

Thus it is self-evident that even in Phase 1 radiation treatment is very essential for the ultimate result of the therapy. I do not favor preoperative radiation treatment in this phase of the disease for the following reasons. In the first place, surgery in this type of case is not only a therapeutic but also a diagnostic measure, and it is imperative not to lose any time. Secondly, I have done, in the course of over thirty years, in institutional and private practice several hundred radical mastectomies and very rarely indeed was a local recurrence encountered after the operation in cases belonging to Phase 1. This shows that, as a rule, no local dissemination of cancer cells takes place as a result of a correctly performed radical mastectomy in properly selected, i.e. Phase 1 cases. Furthermore, a preoperative course of radiation treatment to be effective must be continued for not less than six to eight weeks and during that time transport of cancer cells to distant regions may take place and the case may enter into a more advanced phase of the disease. The need for a prolonged and intensive course of treatment is due to the fact that the primary tumor in carcinoma of the breast is usually more radioresistant than secondary tumors.

On the other hand, postoperative radiation therapy should begin immediately, which means a few days after the operation. The technique of this treatment is based on the assumption that while there

is no gross clinical evidence of distant metastases anywhere, microscopical islands of carcinoma may have entered the lymph and blood channels and found lodgment in certain well defined regions. Without radiation treatment these islands, after months or even years, suddenly develop into large metastatic tumors. The distribution of the lymphatic system shows that the involved regions would be the axillary lymph nodes, the supra- and infraclavicular lymph nodes, the mediastinal lymph nodes, the lungs, the retroperitoneal lymph nodes and the liver. At the same time, through the blood channels, islands of carcinoma cells obtain lodgment in the bone marrow of the skeleton which includes the lower vertebra, the pelvis, the femora and later, most probably throughout the skeleton.

In order to influence both the location of the primary tumors and all the regions in which potentially metastases may develop, I use the following method of postoperative radiation therapy: eight fields, 15 cm. square each, are mapped out, four over the chest consisting of an anterior, posterior and two lateral fields. Four similar fields are mapped out in the region of the pelvis. The conditions of the roentgen therapy are 200 kv., 4 ma., 50 cm. distance, filtration 0.6 mm. copper and 1 mm. aluminum. The treatments are given five or six times a week, 200 r being given daily over one field. In the course of eight weeks each field receives 1,000 r and the total given is 8,000 r. At the same time a block of well screened radon is placed over the supraclavicular region and in the axilla at a distance of 2 cm. from the skin, giving a total of 4,000 millicurie-hours in the course of the eight weeks' treatment. This course of radiation treatment is repeated every six months, in the course of the first two years and every twelve months in the course of the three following years. The patient is examined at frequent intervals throughout these years and roentgen examination of the chest and skeleton is made every six months in the course of the first three years and once a year thereafter. During the period of the radiation treatment, the blood is examined at frequent intervals and, if severe leukopenia develops, then parenteral liver extract injections and iron by mouth are given.

The method described above has been used for the last seventeen years. In the decade previous to this I employed lower voltage and gas tubes and a greater number of fields. The impression is gained that the results obtained by the high voltage methods are superior, but, on the other hand, the general reaction of the blood and blood-forming organs, particularly the leukopenia, is more severe with the present methods of treatment. Whether the use of even higher voltage will further improve the clinical results, future investigations will have to show. It will not, however, replace the use of radium.

The superiority of this planned systematic combination of surgery with radiation treatment over surgery alone is self evident, taking into consideration the therapeutic results of irradiation in malignant conditions generally. It is extremely difficult, however, to offer statistical evidence, particularly since even a five year cure does not mean that the condition may not return later as a local recurrence or metastasis.

PHASE 2: METASTASES IN THE AXILLARY LYMPH NODES

When the lymph nodes in the axilla show a fully developed metastasis, the condition must be considered already in an advanced stage and surgery alone is successful in only 16 per cent of the cases operated upon. However, when both the tumor of the breast and the one in the axilla are freely movable over the chest wall and the underlying tissues, the case is an operable one and requires an immediate radical mastectomy. A preoperative course of radiation treatment is not employed in this phase for the reasons stated in connection with the cases of Phase 1. On the other hand, postoperative irradiation is begun immediately in the operating room. Whenever

a mastectomy is begun, even in cases of Phase 1, gold radon capillaries are prepared in the operating room. As soon as the axillary fat is removed in its entirety each lymph node within the fat is cut across and if a minute island of metastatic carcinoma, which is always very clearly discernible by gross inspection, is found, then the case is considered in Phase 2. Then immediately after the mastectomy is completed capillaries of radon are placed in the axilla and in the area of the chest wall corresponding to the position of the primary tumor and the wound is closed. This is followed by a course of radiation therapy and subsequent treatments as described in Phase 1. The following case illustrates this method of treatment:

CASE IV. S. S., female, aged sixty-five, was seen in October, 1934 complaining of bloody discharge from the left nipple. On examination there was noted a bloody discharge from the left nipple. On palpation, there was felt a tumor mass in the middle of the outer half of the left breast. This tumor was irregularly round in outline, hard and nodular throughout and about 3 cm. in diameter. Anterior to this mass and immediately over the areola there was found another tumor mass about 1 cm. in diameter. There was also felt a diffuse tumor mass in the axilla 3 cm. in length and 1 cm. in thickness. Clinical and roentgen examination showed no distant metastases. On December 18, 1934, I did a radical mastectomy. At operation, the axilla appeared completely filled with metastatic lymph nodes and small metastatic tumors within the axillary fat. Capillaries of radon were inserted in the axilla and over the chest wall in the region of the primary tumor. This was followed by the usual course of radiation treatment.

This case was very extensive and the fact that over three years after the operation there has been found no evidence of local recurrence or metastases indicates the efficiency of this method of treatment.

PHASE 3: METASTASES IN THE SUPRA- AND INFRACLAVICULAR LYMPH NODES

Cases which involve the supra- or infraclavicular lymph nodes and in which the primary tumor and the tumor in the axilla are freely movable may still be considered operable. And again the treatment may begin with a radical mastectomy and insertion of capillaries of radon. In the course of a mastectomy in this phase, I make a separate incision over the clavicle and insert capillaries of radon into this region as well as in the axilla and over the chest wall. Again the previously described type of radiation treatment is begun immediately after the operation.

I have observed many patients who have lived in comfort for a number of years after such treatments. Though it must be clearly understood that in these cases, unlike those of Phases 1 and 2, surgery alone is entirely useless and even with the combined methods as a rule only palliation may be expected. The following case may serve to illustrate this phase:

CASE V. J. S., female, aged fifty, was seen on December 8, 1928, with a history of having noticed a small lump in the left breast two years previously. On inspection, there was noted in the left breast immediately above the nipple a diffuse swelling about 4 cm. in diameter. Immediately above the swelling there was noted a dimpling of the skin. On palpation, there was found in the area of the elevation a hard and nodular mass about 4 cm. in diameter and 2 cm. in thickness. The mass was freely movable over the chest wall. There was a diffuse flat mass palpated in the axilla freely movable over the underlying structures. Two nodules the size of a buckshot were palpated in the supraclavicular region. No metastases were found elsewhere. A diagnosis was made of carcinoma of the left breast with metastases in the axillary and supraclavicular lymph nodes. On December 21, 1928, I did a radical mastectomy and radon insertion into the axilla and the chest wall. An additional incision was made perpendicular to the clavicle and supraclavicular nodes were removed and radon inserted into the region. This was followed by the usual radiation treatment.

The patient lived for six years after the operation and died then of pulmonary metastases.

PHASE 4: ULCERATED CARCINOMA OF THE BREAST

In previous phases, surgery remains the major method of therapy and the radia-

tion treatment a very important adjuvant which must follow and not precede surgery. In the following phases irradiation is the major procedure, it always precedes surgery, and the latter is employed only occasionally.

Carcinoma of the breast ulcerates late in its development and must be accompanied by metastases in all the lymph nodes and frequently in the skin surrounding the ulcerated tumor (carcinoma en cuirasse).

A patient suffering from a large ulcerating tumor of the breast which secretes a foul discharge is a burden to herself and to her surroundings and demands immediate relief. When there is no evidence of multiple metastatic nodules in the skin surrounding the ulcerating tumor, the case is treated in the following manner. The redundant ulcerated tumor may be removed by diathermic coagulation and then an insertion of radon capillaries is made into and around the ulcerated area of the tumor and this is followed by surface application of radium and by roentgen therapy. After a period of about six weeks the ulcer generally becomes diminished in size, or even becomes covered with epidermis, and the tumor becomes more freely movable over the chest wall. A mastectomy is then done, with the removal of the pectoral muscles and with a more or less complete cleaning of the axilla, depending on the condition found. Only enough skin is removed to excise widely the ulcerated area and to allow for an immediate primary union.

It must be clearly understood that this represents only a palliative procedure. It seems, however, not only to prolong life but mainly to make the life of the patient more bearable. It is much more comfortable for the patient both bodily and mentally to succumb ultimately to internal metastases than to live for months with a large fungating carcinomatous ulcer. The following cases serve to illustrate this group:

Case vi. S. C., female, aged fifty-nine, was seen on May 22, 1924, with advanced carcinoma of the right breast. On examination there was found a stony hard mass in the upper half of the breast. It was about the size of a grapefruit and was attached to the skin but was movable from the deep structures. There was an ulceration, roughly circular in outline and 6 cm. in diameter, overlying the central part of the tumor. The right nipple was drawn upward toward the tumor. In the right axilla there was a large hard mass which was movable over the underlying tissues. No distant metastases were noted. On June 21, radon capillaries were inserted into the ulcerated area of the breast. The tumor shrank and the ulceration diminished in size. A mastectomy was performed on July 24. The wound healed by primary union and the patient improved rapidly in her general condition. When she was last seen, sixteen months after the operation, there was no evidence of any local recurrence or metastases.

Case vii. M. D., female, aged seventy-seven, was seen on August 3, 1929. On inspection there was noted, 3 cm. above and to the right of the nipple of the right breast, a round ulcer, pinkish-red in color, 2 cm. in diameter somewhat elevated above the surface of the breast. On palpation the base of the ulcer was very hard and was attached to a diffuse mass which occupied the right upper quadrant of the breast. The right axilla contained lymph nodes hard in consistency. The diagnosis of carcinoma was made. On August 27, capillaries of radon were inserted into the ulcerated area of the tumor. On September 5, the mass appeared smaller in size and softer in consistency. On October 29, a mastectomy was done. The wound healed by primary union and the local and general condition was good when last seen two years later.

In all these cases mastectomy was followed by the usual course of radiation treatment.

PHASE 5: BREAST TUMORS ATTACHED TO THE CHEST WALL

In all the cases of this phase the tumor is attached to the chest wall and, as long as this condition lasts, surgical removal is contraindicated, since an immediate severe local recurrence would follow the operation. In this group therefore, radiation therapy is the only method to employ in the majority of cases. Whether the primary

breast tumor is ulcerated or not, an insertion of radium should be made into the primary tumor and into the axillary metastases, which are always present in these cases. This is followed by the usual course of radiation treatment. The tumor usually shrinks under this treatment, and the ulceration may become covered with an epidermis.

In a certain number of these cases the tumor not only shrinks but becomes movable over the chest wall. In such an instance a palliative mastectomy may be performed with temporary benefit and possible prolongation of life. In the following cases the tumors became movable after the intratumoral insertion of radon.

CASE VIII. M. E., female, aged sixty-three, was seen on May 21, 1925. On examination of the right breast, the nipple was found replaced by a hard indurated mass. Another mass was noted in the lower outer quadrant of the breast, ulcerated in the center. Both masses were firmly adherent to the chest wall. The diagnosis of carcinoma was made. On June 10, 1925, a radon insertion was done into the two carcinomatous masses of the breast. This was followed by the usual course of radiation treatment. On August 3, the tumors were found to be freely movable over the chest wall, and on August 12, a palliative mastectomy was done. The wound healed by primary union and when the patient was seen last, eighteen months later, there was no evidence of any local recurrence.

CASE IX. G. M., female, aged sixty, was seen on February 29, 1924. On examination of the left breast there was noted in the upper outer quadrant a tumor mass measuring 6 by 2 cm. firmly adherent to the chest wall and ulcerated in the center. On March 27, radon capillaries were inserted into the tumor. By the end of April the tumor appeared smaller in size and freely movable over the chest wall. On May 6, a palliative mastectomy was done, the wound healed by primary union. On February 3, 1925, roentgen examination showed the appearance of skeletal metastases. The patient died May 5, about fifteen months after the beginning of the treatment.

This purely palliative treatment of these patients certainly added greatly to their comfort.

PHASE 6: LOCAL RECURRENCE AFTER MASTECTOMY

Local recurrence after mastectomy in and around the scar may take place many years after a radical mastectomy, even without having shown, throughout these years, any evidence of distant metastases. These recurrent tumors are adherent to the chest wall and must therefore be treated by the aid of the same technique as was indicated in Phase 5. The only surgical procedure in this type of case consists of an incision over the tumor mass so as to facilitate the introduction of radon capillaries and doing a biopsy. This then is followed by a course of radiation therapy described above. Should the recurrent tumor appear to be freely movable over the chest wall, then a wide excision can be done followed by insertion of radon capillaries and a course of radiation therapy. The following cases illustrate this phase of carcinoma of the breast:

CASE X. A. E., female, aged fifty-eight, had a radical mastectomy done for carcinoma of the left breast with involvement of the axilla, in September, 1926. On October 31, 1927, a local recurrence appeared in the sternocostal junction corresponding to the third and fourth ribs. I made an incision over the tumor mass, performed a biopsy, which gave positive results, and inserted radon capillaries. This was followed by the usual course of radiation therapy. At present, nearly ten years after the mastectomy, there is no evidence of any local recurrence of metastases anywhere, and the patient is comfortable and takes care of her work.

CASE XI. D. C., female, aged fifty-two. The patient had a radical mastectomy in January, 1927. This was followed by a course of radiation therapy, at the New York City Cancer Institute, under my direction. The patient then moved to Washington, D. C., and had there one year more of radiation treatment. After this she had no further treatment, until a local recurrence appeared in November, 1936. She was then seen by me and, on examination, a tumor mass was found, irregularly round in outline, measuring 3 cm. in diameter, freely movable, both over the chest wall and skin. It was situated to the right of the mastectomy scar and

at the level of the fourth rib. Clinical and roentgen analysis showed no evidence of any distant metastases. On December 2, 1936, a wide excision was done of the tumor mass, with insertion of radon into the operative field and a course of radiation treatment. At present the would is healed and there is no evidence of recurrence of metastases anywhere.

Carcinoma in the second breast is a condition which therapeutically must be handled practically in the same manner as the cases of Phase 6.

The development of a malignant tumor in the second breast in a patient with carcinoma of the breast is not a very rare occurrence. It is difficult to determine in each individual case whether the tumor which developed in the second breast is a second primary malignancy or a metastatic tumor from the first breast. The treatment, however, remains the same in both instances. The tumor in the second breast, if left untreated, will increase rapidly in size and will become an active source for the formation of the new metastases. Therefore, if the general condition of the patient is favorable, the second breast should be removed surgically and this followed by radiation treatment. In this manner very excellent palliative results may be obtained.

Handley[5] reported in great detail the clinical course of one patient who had a left mastectomy done in 1912, followed by roentgen treatment and radium insertion. Ten years later a right mastectomy was done. The patient died two years later, or twelve years after the first operation, from metastases in the lungs. The following are similar cases from my practice.

CASE XII. E. C., female, aged twenty-four, was seen on April 29, 1921, with carcinoma of the left breast and a large tumor in the axilla. A radical mastectomy was performed and capillaries of radon inserted into the axilla and the part of the chest wall corresponding to the position of the primary tumor. This was followed by a course of radiation treatment. In October, 1921, a tumor was found in the right breast with involvement of the axilla. A mastectomy of the right breast was done with insertion of radon, which was then followed by a course of radiation treatment. The patient died on January 19, 1929, nearly eight years after the first operation, of pulmonary metastases. With the exception of the last few weeks, the patient was well throughout the eight years.

CASE XIII. A. S., female, aged forty, came for examination on October 1, 1925, with a history that a right mastectomy for carcinoma was done on January 4, 1924. The patient, complained of severe headache. Examination showed a hard nodular mass in the inner lower quadrant of the left breast. Roentgen examination of the skeleton showed an irregular destruction in the inferior surface of the body of the fourth lumbar vertebra. Diagnosis was made of metastases in the body of the fourth lumbar vertebra and in the left breast. On October 18, 1925, I did a left mastectomy. Miscroscopical analysis showed adenocarcinoma. This was followed by repeated courses of radiation treatment. At present, nearly ten years after the first mastectomy, the patient is in good condition and shows no new metastases.

PHASE 7: METASTASES IN THE LUNGS

The life of a patient with pulmonary metastases secondary to carcinoma of the breast is short and extremely uncomfortable. The condition is hopeless and, as a general rule, irradiation does not improve it. Nonetheless, all these patients should be given the benefit of radiation treatment, since occasionally striking temporary improvement may be obtained, as is well seen in the following case:

CASE XIV. M. P., female, aged thirty-nine, was seen on March 25, 1930, with a history of having noticed a mass in the right breast eighteen months previously and an ulceration for the last six months. The patient also complained of dyspnea and cough. On examination the right breast was found transformed in its entirety into a flat hard and nodular tumor mass, firmly adherent to the chest wall. Surrounding and partly undermining the nipple there was a flat ulceration measuring about 8 cm. in diameter. A hard and nodular tumor was found in the axilla. On percussion of the chest, the right side showed dullness everywhere and on auscultation total loss of breath sounds. Roentgen analysis of the chest on March 25,

1930, showed a diffuse opacity of the right chest extending up to the level of the second intercostal space, obliterating the dome of the diaphragm, the costophrenic sinus and right cardiac border. A diagnosis of carcinoma of the breast with metastases to the pleura and lungs was made. On March 27, a thoracocentesis was done and 1,000 cc. of straw-colored fluid was obtained; then a specimen of tissue for a biopsy was taken from the ulcerated area, which confirmed the diagnosis, and radon capillaries were inserted into the tumor of the breast and of the axilla. On June 20, the thoracocentesis and the radon insertion were repeated. Roentgen analysis of the chest on June 21, 1930, showed the upper level of the fluid at the fourth right rib anteriorly. The upper portion of the chest showed pneumothorax. The radon capillaries were visualized. This was followed by radiation treatment. No further thoracocentesis was necessary; the ulcerated area became covered with epidermis. Roentgen analysis on July 22, 1930, showed the pneumothorax to have disappeared and the lung expanded. On March 17, 1931, roentgen examination showed a further increase of the clear area of the right lung. Meanwhile neither the tumor of the breast nor the one in the axilla was palpable at the time. The patient lost her distressing symptoms of cough and dyspnea and felt clinically well until April, 1931, when suddenly symptoms of cerebral metastasis developed and she died on April 16.

The therapeutic result of irradiation in this case was certainly remarkable, and had it not been for the cerebral metastasis which is comparatively infrequent in cancer of the breast, the patient's life might have been prolonged still further. It is probable that the insertion of radon capillaries into the tumor of the chest wall contributed considerably to the success in this case.

PHASE 8: SKELETAL METASTASES

Most remarkable results are obtained occasionally in the treatment of skeletal metastases secondary to carcinoma of the breast by the aid of radiation treatment. I have previously reported[6] several such cases, but the following case may well illustrate such results:

CASE XV. T. C., female, aged thirty-six, was seen on March 22, 1922. She was suffering with paraplegia and severe pain in the back. Roentgen examination showed metastases of the skeleton, involving the dorsal and lumbar spine and all the pelvic bones, as well as the skull. Subsequently the cervical spine also became involved, so that the patient was lying rigid in bed without being able to move either the lower extremities or the head. The patient remained at the hospital for two and one-half years, until late in November, 1924. In the course of her stay at the hospital she received surface radium applications and roentgen treatments practically throughout the whole skeleton. She gradually began to improve, so that toward the end she was able to walk without any support or help, had practically no pain anywhere, and at her own request she was discharged in November, 1924. Examination of the skeleton revealed a great deal of new bone formation throughout the skeleton.

This case is remarkable in view of the immense quantity of metastatic carcinoma present throughout the organism and also in view of the la ge amount of therapy that the patient received in the course of the two and one-half years. The clinical result is very striking. While it is fairly certain that the carcinoma tissue had not all been destroyed within the organism, a bedridden patient with paralysis of both lower extremities, with severe pain on the least movement of any joint, was able to leave the hospital in such a condition that she could walk about and take care of herself.

PHASE 9: METASTASES IN THE LIVER

All of the eight phases of carcinoma of the breast described above require combined surgical and radiation treatment. There is either a chance, be it ever so small, of obtaining permanent results or as in Phases 4, 7 and 8 the symptoms are so distressing that the need for some palliative treatment is imperative. Metastases in the liver, whether or not accompanied by general intraperitoneal carcinomatosis, develop extremely rapidly and the patient soon succumbs. Moreover, unlike metastases in the supraclavicular lymph nodes,

lungs or skeleton, metastases cause no symptoms outside of some gastric disturbances, vomiting and general asthenia.

In view of this, radiation treatment is not indicated in this phase of the disease.

SUMMARY

The clinical course of cancer of the breast depends to a much lesser extent on the microscopical characteristics of the primary tumor than upon the rapidity of the invasion of the surrounding tissues by the primary tumor and of the development and the location of the metastases. These characteristics of the clinical behavior of cancer of the breast influence the selection of the correct methods of treatment. In relation to these clinical characteristics carcinoma of the breast may be divided into the following nine phases, each of which requires a different therapeutic approach.

Phase 1 embraces the cases in which there is no evidence of invasion of surrounding tissues or of formation of metastases. In this early phase of the disease the diagnosis offers great difficulties, particularly when malignancy develops on the basis of chronic cystic mastitis. Surgery in this phase acts both as a diagnostic and therapeutic procedure. I do not employ preoperative but only postoperative radiation treatment.

Phase 2 represents cases with metastases in the axillary lymph nodes and *Phase 3* with metastases in the supra- and infraclavicular lymph nodes. In both of these phases a radical mastectomy is performed with an immediate insertion of gold capillaries of radon, followed by radiation treatment.

Phase 4 represents cases in which the primary tumor is ulcerated, *Phase 5* represents cases in which the primary tumor is attached to the chest wall, and *Phase 6* cases of local recurrence after mastectomy. In these three phases radiation treatment is the main procedure but surgical removal of the irradiated tumor may follow.

Phase 7 represents cases with metastases in the lungs and *Phase 8* in the skeleton. Good palliative results may be obtained by radiation treatment in these two phases.

Phase 9 represents cases with metastases in the liver and with generalized carcinomatosis. No radiation treatment should be given in this phase.

Not more than 15 per cent of all the patients suffering from carcinoma of the breast who come for treatment are in Phase 1, i.e. in the truly early stage of the disease. Patients in the other eight phases of the disease, which together comprise 85 per cent of all the patients, are in an advanced stage of the disease. These advanced cases present to date the most pressing problem in the treatment of carcinoma of the breast. However, a great deal of relief can be offered these patients by correct coördination of surgery and radiation treatment.

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IONIZATION IN AIR AND IN GAS MIXTURES APPROXIMATING COMPOSITION OF TISSUES*

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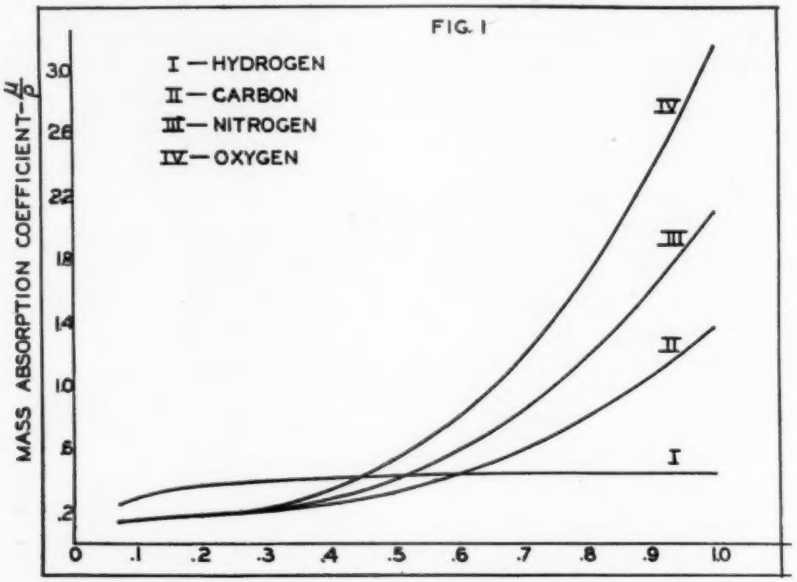
INTRODUCTION

IT IS generally considered reasonable to assume that the biological action of ionizing radiation should ultimately depend on the ionization produced in the living tissue. The determination of the roentgen, which has been adopted as a unit of x-ray quantity, involves only the measurement of the ionization produced in air by roentgen radiation under certain stipulated conditions. But when one considers the roentgen in relation to the x-ray dose, which is of paramount importance in radiation therapy, one is confronted with the tacit assumption of a constant relationship between roentgen-ray ionization in air and that produced in tissues. The acceptability of this assumption rests on the fact that both air and tissues are essentially composed of light elements, which interact with roentgen rays in a similar way. This constant relationship between air and tissue ionization is perhaps accurate when considering monochromatic roentgen rays from 100 kv. upwards, as has been discussed by Lauritsen,[4,5] but it is certainly questionable for radiation below that voltage, where the photoelectric effect cannot be neglected.

FIG. 1



That component of the absorption coefficient, which governs the photoelectric effect, is known to vary as the fourth power of the atomic number Z and as the cube of the wave length λ. Therefore, the difference in the atomic numbers of the elements constituting air and living tissues should introduce an appreciable difference in the energy absorbed in these media by soft and medium roentgen rays, such as those employed in therapy. The probable existence of this difference may be deduced from the curves given in Figure 1. These curves ex-

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

press the relation between the mass absorption coefficients of hydrogen, carbon, nitrogen and oxygen and the wave lengths corresponding to effective voltages ranging from 12 to about 120 kv. The data were compiled by S. J. M. Allen and are published by Compton and Allison.[1] The purpose of reproducing graphically these well-known data is, primarily, to stress the difference in the absorption of roentgen rays in hydrogen, which is practically constant over the voltage wave length range considered, and in other gases where the absorption increases rapidly with increasing wave length.

The composition of air, by volume, is known to be: nitrogen 78 per cent and oxygen 21 per cent. The composition of the body, as given by Sherman,[6] is: oxygen 65 per cent, carbon 18 per cent, hydrogen 10 per cent, and nitrogen 3 per cent, by weight, the rest being inorganic matter. One can calculate, by means of the graphs given in Figure 1, the difference in roentgen-ray absorption in air and that in a gas mixture similar to the soft tissue composition, in which very little inorganic matter is found. The computed values do, in fact, show that the ratio of the energy absorbed in a gas mixture of this composition to that in air increases with increasing voltage up to about 100 kv. effective. It is desirable, however, to make a direct comparison experimentally, under proper conditions. This can be done by measuring the ionization produced under suitable conditions in a gas mixture, of the desired composition, and in air, and determining how the ratio of the two varies with the voltage.

EXPERIMENTAL

In order to compare the ionization produced in gas mixtures of different atomic composition, it is essential that the secondary electrons which are directly responsible for the ionization originate in the gas itself and not in the walls of the chamber, or other parts of the apparatus. Obviously, the ionization chamber must also be a closed one. Previous experience at the Memorial Hospital had shown that a chamber of the mesh type agrees with the standard open air chamber over a very wide range of wave lengths, provided certain simple precautions are taken. The mesh type chamber has the advantage of being much smaller than an equivalent standard open air chamber and therefore can be enclosed more readily in a gas tight container. This is an important point in the case of gas mixtures which are explosive, requiring the use of thick-walled containers. The construction of the chamber used for these experiments is shown in Figure 2.

The enclosure consists of a cylindrical steel tank, *A*, 15 cm. in diameter and 25 cm. high, with walls 6 mm. thick. The bottom plate is welded to the cylinder while the top plate is bolted, making a vacuum tight joint by virtue of a narrow solder gasket. The electrodes, *B*, consist of three brass rings, as shown, to which are attached parallel aluminum wires, about 0.04 mm. in diameter, spaced about 5 mm. apart. The two outer grids are mounted rigidly 25 mm. apart on three supporting metal stirrups, *C*, which in turn are attached to the steel cylinder through insulated posts, *D*, as shown. The third electrode is mounted on three other insulated posts and midway between the outer electrodes. Since the chamber is intended to be used later for the measurement of roentgen-ray ionization in vapors of complex organic materials at temperatures in the neighborhood of 100° C., amber could not be used for insulation. Small automobile spark plugs with good porcelain insulation were found to be very satisfactory for this purpose—especially since vacuum tight joints could be made readily by soldering the metal sleeves of the plugs to suitable brass extensions brazed to the steel cylinder. Not all spark plugs have sufficiently high insulation for this purpose. "Champion J-8" plugs were found by test to give a negligible leakage current of less than 10^{-15} ampere with 100 volts potential difference. Both in the case of the two outer electrodes and the middle one, electrical connections are effected through one of the three insulating posts, respectively. The two outer electrodes are connected to a dry battery which provides the necessary voltage for saturation current. The center electrode is connected to the current measuring device. Since all insulators are mounted on the steel cylinder which is grounded, and the central electrode is maintained at ground potential during a measurement (null method), the best conditions of guard ring protection are realized.

The roentgen-ray beam enters the steel cylinder through circular apertures in the removable end plate, *E*, and associated lead disk. The window is made vacuum tight by a celluloid disk, *F*, 0.8 mm. thick, under compression at the periphery. Lead diaphragms, *G*, of the desired aperture may be placed in the external recess. The radiation beam is normal to the three parallel electrodes. The volume in which the ionization is measured in this type of chamber is determined by the area of the limiting diaphragm and the spacing of the two outer electrodes. Since the limiting diaphragm is close to the "ionized volume," previous experience has shown that secondary electrons produced at the edges of the diaphragm may contribute to the ionization. This occurs when the wave length of the radiation is shorter than that of the characteristic radiation of the material of the diaphragm. For this reason the roentgen-ray beam is collimated by a series of lead diaphragms placed ahead of the celluloid window—which absorbs any spurious secondary electrons.* Beyond the electrodes the well defined and narrow beam of roentgen rays passes through a diaphragm, *H*, of larger cross-section than itself and is finally absorbed by the lead plate at the bottom of the steel enclosure. Previous experience has proved that the lower compartment of the chamber constructed as shown and separated by this diaphragm acts as an effective trap for the radiation and no appreciable amount is scattered back to the level of the electrodes.

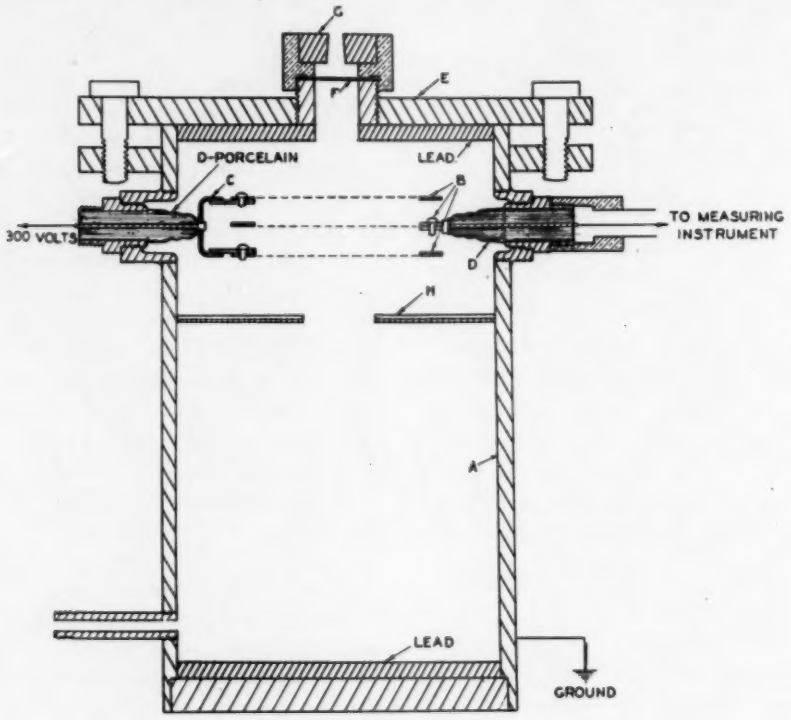


FIG. 2

The roentgen-ray source was a constant potential generator with an air-cooled tube. To cover the range of voltages from 25 to 200 kv., two different roentgen-ray tubes were used: a thin-walled tube for voltages below 100 kv. and a thick-walled tube for voltages from 100 to 200 kv. The quality of the roentgen-ray beam at different voltages was determined by obtaining absorption curves in aluminum or copper.

The ionization current was measured by a null method, and the detection of the balance of the two currents was done by means of a vacuum tube circuit as described by Failla.[2] This method of measurement has an extremely wide range of sensitivity and enables rapid readings. The stability of the roentgen-ray beam was maintained by controlling, as care-

* In a certain sense the secondary electrons produced in the celluloid may also be considered to be "spurious" (vide infra).

fully as possible, the voltage in the primary of the transformer and by keeping the tube current constant in the course of the measurements. By repeated readings for a given point, and by checking the results a few times, it was found that the fluctuations in the values of the current were well within 5 per cent of the average, even for very low current values. This precision was considered sufficient for these experiments, which are only of a preliminary nature.

The general composition of the body by weight (as mentioned already) is: hydrogen 10 per cent, carbon 18 per cent, nitrogen 3 per cent, oxygen 65 per cent, with 4 per cent of inorganic matter, in which calcium, 1.5 per cent, and phosphorus 1 per cent, predominate. The four major components of the body closely approximate the composition of soft tissues which are known to contain only 1 per cent of inorganic matter. By converting the percentages by weight into corresponding percentages by volume one finds the tissue composition to be: hydrogen 57.8 per cent, carbon 17.4 per cent, nitrogen 1.2 per cent, and oxygen 23.5 per cent. Carbon dioxide was utilized to obtain the required amount of carbon. The partial pressures in centimeters of mercury of the different gases were: hydrogen 53.2, carbon dioxide 16, nitrogen 1.2 and oxygen 5.6. Thus the total pressure of the mixture was 76 cm.

The gases were obtained in metal containers at high pressures. Their purity was given to be at least 99 per cent with only traces of air as impurity. The introduction of the gases into the steel tank at the required pressures was carefully controlled by a mercury manometer. The highly compressed gases in their metal container were first let into a thick-walled rubber balloon so as to obtain a pressure slightly above that of the atmosphere and from there into the steel tank. The evacuation of the apparatus before the introduction of the different gases was done by means of a two stage vacuum pump.

RESULTS

The steel tank was at first filled with air and the temperature and the barometric pressure were noted. Then the ionization currents with roentgen-ray beams produced at different voltages were measured, taking five readings for each determination and checking the readings at least three times at different intervals. Then, while the tube was still running, the steel tank was rapidly evacuated and the four gases at their appropriate partial pressures were introduced, bringing the total pressure close to that of the air. The temperature was again noted, so that any corrections for temperature difference could be made when necessary.

Table I

Voltage kv.	External Filter	Half-Value Layer mm. Al	Eff. Voltage kv.	Eff. λ Å	Ionization Ratio Mixture/Air	
					at 76 cm. Hg	at 152 cm. Hg
25	0	0.55	16	0.77	0.39	0.84
50	0	0.95	21	0.59	0.40	0.84
100	1.08 mm. Al	5.95	46	0.27	0.42	0.88
150	0.15 mm. Cu +1.08 mm. Al	8.75	59	0.21	0.44	0.93
192	2.12 mm. Cu +1.08 mm. Al	15.10	104	0.12	0.48	1.00

In the beginning, while working with soft roentgen rays, it was thought of interest to determine the differences in ionization in air and in gas mixture for different parts of the continuous spectrum of a beam at a given voltage. Therefore ionization currents were measured for different parts of the spectrum by interposing eight different aluminium filters varying in thickness from 0.1 mm. to about 4 mm. The results thus obtained indicated clearly that in the region of soft roentgen rays, the

variation in the value of the ratio between ionization in air and in gas mixture was within the limits of experimental errors.

The range of voltages covered in the experiments extended from 25 to 192 kv. The results obtained therefrom are given in Table 1. The given values are averages of the best determinations. Since a simple computation revealed that the electron density of the mixture was only 51 per cent of that of air, it was decided to check the variation of ionization in the gas mixture by doubling its pressure in the steel tank. It was thought of importance to do this in order to reduce the electron tracks in the gas mixture to the corresponding track lengths in atmospheric air. With the longer electron paths one could not be sure that the chamber electrodes were large enough for complete utilization of the secondary electrons, since the comparison with the standard open air chamber had been made previously only with air at atmospheric pressure. The experimental procedure for measuring the ionization in the mixture at 152 cm. of mercury and in air at normal pressure for roentgen rays at different voltages was identical with the one previously described. The values of the ratio of the ionization in the gas mixture and air of the same electron density are given in the last column of Table 1.

DISCUSSION

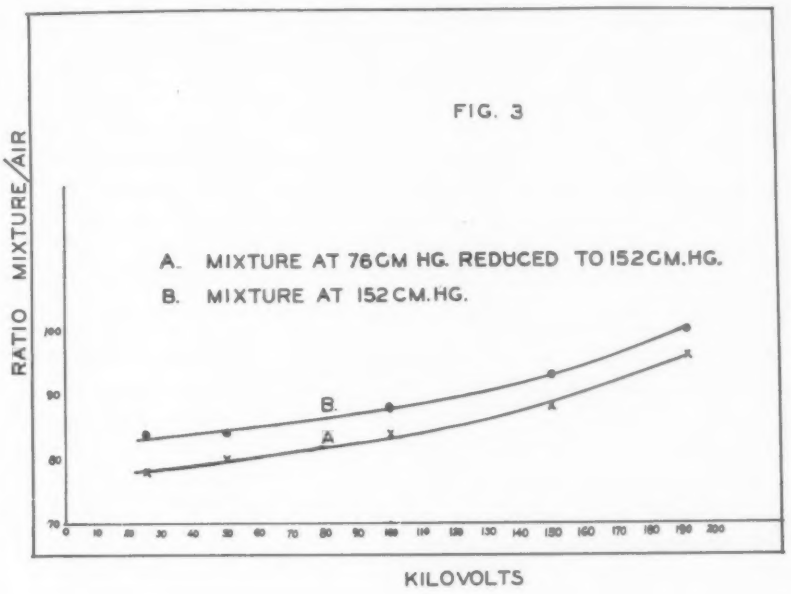
It is rather difficult to appraise closely all the probable errors involved in the determinations. Some of the experiments were performed in hot, damp weather under conditions which were not favorable for great accuracy. However, since the readings were taken in air and in gas mixtures, in rapid succession under conditions as nearly alike as possible, the probable error on the ratio is presumed to be well below 5 per cent. The results presented in Table 1 reveal clearly that the relation between ionization in air and in the gas mixture is not constant over the range of voltages usually utilized in roentgen therapy, if one leaves aside the so-called supervoltages. The ratio increases with increasing voltage from 25 to 192 kv., as given by a deep therapy machine, or the estimated range of effective voltages from 16 to 104 kv.

The variation of the ratio can be accounted for qualitatively on the basis of the difference in effective atomic numbers between air ($Z_{eff.}=7.69$) and gas mixture ($Z_{eff.}=6.80$) calculated according to the formula[3]:

$$Z_{eff.}=\sqrt[3]{\frac{n_1Z_1^4+n_2Z_2^4+n_3Z_3^4+\cdots}{n_1Z_1+n_2Z_2+n_3Z_3+\cdots}}$$

where n_1, n_2, etc., are numbers of atoms in unit mass of the mixture of elements whose respective atomic numbers are Z_1, Z_2, etc. At the lower voltages, where the photoelectric effect predominates, the ionization in the mixture is relatively lower than in air. Plotting curves (Fig. 3) of the ratios in Table 1 against voltage to average out discrepancies, it is found that the ionization ratio increases about 22 per cent as the voltage varies from 25 to 192 kv. It is important to note the trend of the curves of Figure 3 since it indicates that the ratio has not reached a steady value, but, on the contrary, may be expected to increase considerably with voltages higher than 192 kv. If the increase is due to photoelectric absorption, it is evident that this process is still important in the ordinary 200 kv. range of roentgen rays. No doubt the increase is also partly due to the high mass absorption coefficient of hydrogen as compared to those of carbon, nitrogen, oxygen in this wave length region. Curves A and B (Fig. 3) should coincide inasmuch as the ratios for the mixture at 76 cm. Hg pressure were doubled before plotting Curve A, in order to reduce them to the same pressure at which the values of Curve B were obtained. The fact that Curve A is lower than Curve B indicates that at the lower pressure the secondary electrons were not fully utilized in the gas mixture. Since the range of the electrons is a function of the wave length, one would not expect the percentage difference between the two curves

to be substantially the same throughout as it is in Figure 3. However, it is not unlikely that in the wave length range involved here, the *average* secondary electron range does not vary greatly. For, in the lower voltage region the photoelectric effect predominates and the secondary electrons carry practically the full amount of energy of the photons, whereas in the higher voltage region the Compton effect predominates and in general only a fraction of the photon energy is imparted to the recoil electron.



Since the ratio between the ionization in the gas mixture at 152 cm. Hg pressure and that in air at normal atmospheric pressure is one for (filtered) 192 kv. roentgen rays, the actual number of ion pairs per second produced in the chamber was the same in both cases. This, however, is a mere coincidence and has no particular significance. From the trend of the curves in Figure 3, it is obvious that the ratio would be greater than one for still harder roentgen rays. The important point is that the ratio is not constant in the voltage range investigated and probably for considerably higher voltages. This means that ionization in air *per se* is not a satisfactory basis for the measurement of roentgen-ray dosage. For the proper correlation of dose and effect it is desirable to express the dose in terms of something which bears a constant relation to the energy absorbed by the living tissue, for all wave lengths. Ionization in air evidently does not satisfy this requirement. This is particularly true when the ionization is measured by means of the conventional standard open air chamber. In the case of small closed chambers of the thimble type, the ionization is due largely to secondary electrons originating in the walls. In this case it is theoretically possible to choose the wall material and size of the chamber so that the ionization in the enclosed air bears the same proportional relation to the energy absorbed in a given time, for a very wide range of wave lengths. The accepted practice of calibrating thimble chambers against a standard open air chamber, makes the chamber suitable for the measurement of x-rays in roentgens (according to the present definition), but it does not make it suitable for the measurement of tissue doses.

Mention should be made of the possible influence of the celluloid window of the ionization chamber on the results of the

experiments reported here. Some secondary electrons liberated in the celluloid undoubtedly reach the volume in which the ionization is measured. This, however, would tend to decrease the difference in ionization found between air and gas mixture, and does not vitiate the general conclusion.

The presence in living tissues of elements of fairly high atomic numbers, even in very small proportions, may be expected to contribute considerably to the absorption of energy, when the photoelectric process predominates. Experiments to test this point are now in progress, making use of the same apparatus.

SUMMARY

A comparison of the ionization produced in air and in a gas mixture approximating the atomic composition of human soft tissues has been made with roentgen rays of effective wave length ranging from 0.12 to 0.77Å.

The ratio of the ionization in the gas mixture to that in atmospheric air decreases with increasing wave length, and the difference is about 22 per cent in the above mentioned range.

Qualitatively, the difference may be attributed to the difference in the effective atomic numbers of air and the gas mixture and to the "anomalous" variation of the mass absorption coefficient of hydrogen with respect to wave length in the region of these experiments.

Since in radiation therapy it is desirable to express tissue doses in terms of the energy absorbed by the living tissue, ionization measured in air does not fulfill the necessary requirement in the wave length range ordinarily used.

The experiments described in this paper have been carried out in the Physics Laboratory of the Memorial Hospital. I wish to thank Dr. Failla for suggesting the problem and other members of the staff whose help and encouragement have been most valuable.

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HALF-VALUE LAYER MEASUREMENTS WITH A 1,000 KV. ROENTGEN TUBE

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ABSTRACT

ROUGH theoretical considerations indicate that the monochromatic equivalent of a roentgen-ray beam, as determined in copper, may be quite different from that obtained in water for the range of 200 to 400 kv., converging to the water value on both sides of this region. Experiments made at various voltages and with various filters on a high voltage tube show that this disagreement may amount to 20 to 25 per cent. For this reason it is felt that copper is not a satisfactory material for characterizing beams in this range.

INTRODUCTION

In the comparison of results obtained by the use of gamma rays and roentgen rays produced at various voltages, the necessity for a standard measure of the so-called quality of the radiation is apparent. The most generally adopted standard for comparison of quality is the half-value layer, i.e., that thickness of some absorbing material which attenuates a narrow primary beam to 50 per cent. From the half-value layer and the known variation of the absorption coefficients with wave length may be deduced the "monochromatic equivalent," i.e., that one wave length which has the same attenuation as the beam in question.

Because of the fact that the process by which this monochromatic equivalent is

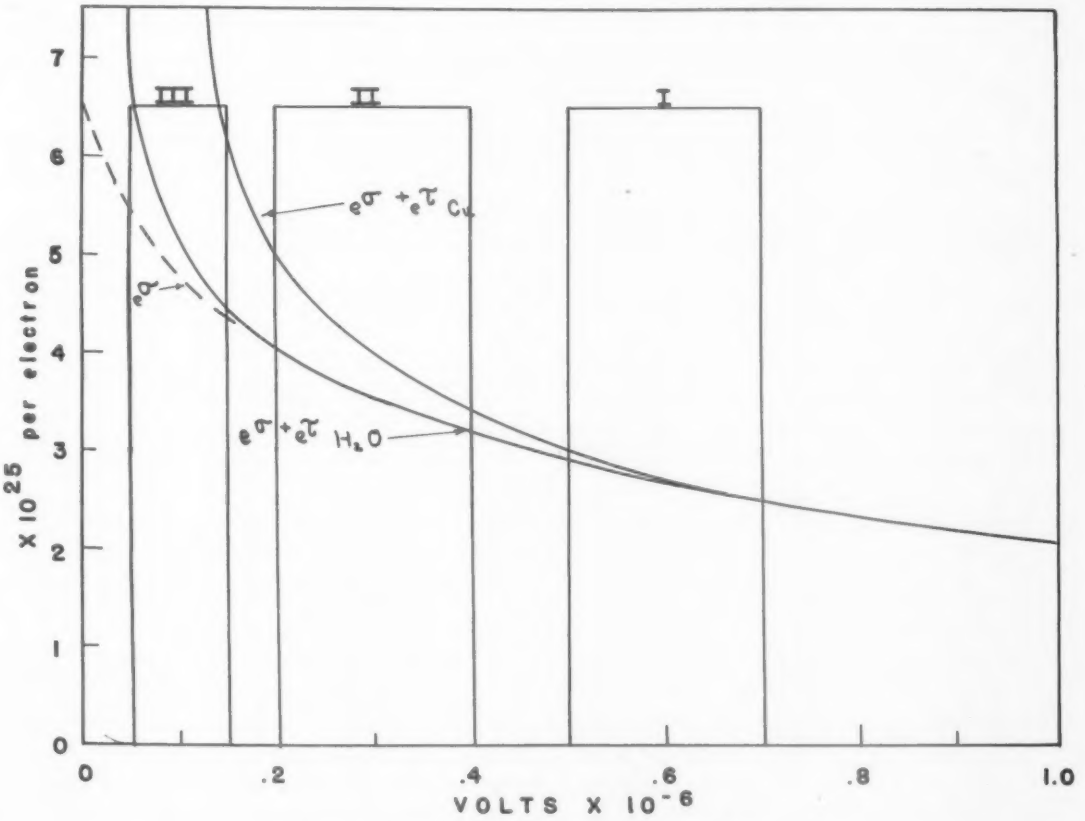

FIG. 1. Simplified case of uniform distribution.

experiments reported here. Some secondary electrons liberated in the celluloid undoubtedly reach the volume in which the ionization is measured. This, however, would tend to decrease the difference in ionization found between air and gas mixture, and does not vitiate the general conclusion.

The presence in living tissues of elements of fairly high atomic numbers, even in very small proportions, may be expected to contribute considerably to the absorption of energy, when the photoelectric process predominates. Experiments to test this point are now in progress, making use of the same apparatus.

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HALF-VALUE LAYER MEASUREMENTS WITH A 1,000 KV. ROENTGEN TUBE

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ABSTRACT

ROUGH theoretical considerations indicate that the monochromatic equivalent of a roentgen-ray beam, as determined in copper, may be quite different from that obtained in water for the range of 200 to 400 kv., converging to the water value on both sides of this region. Experiments made at various voltages and with various filters on a high voltage tube show that this disagreement may amount to 20 to 25 per cent. For this reason it is felt that copper is not a satisfactory material for characterizing beams in this range.

INTRODUCTION

In the comparison of results obtained by the use of gamma rays and roentgen rays produced at various voltages, the necessity for a standard measure of the so-called quality of the radiation is apparent. The most generally adopted standard for comparison of quality is the half-value layer, i.e., that thickness of some absorbing material which attenuates a narrow primary beam to 50 per cent. From the half-value layer and the known variation of the absorption coefficients with wave length may be deduced the "monochromatic equivalent," i.e., that one wave length which has the same attenuation as the beam in question.

Because of the fact that the process by which this monochromatic equivalent is

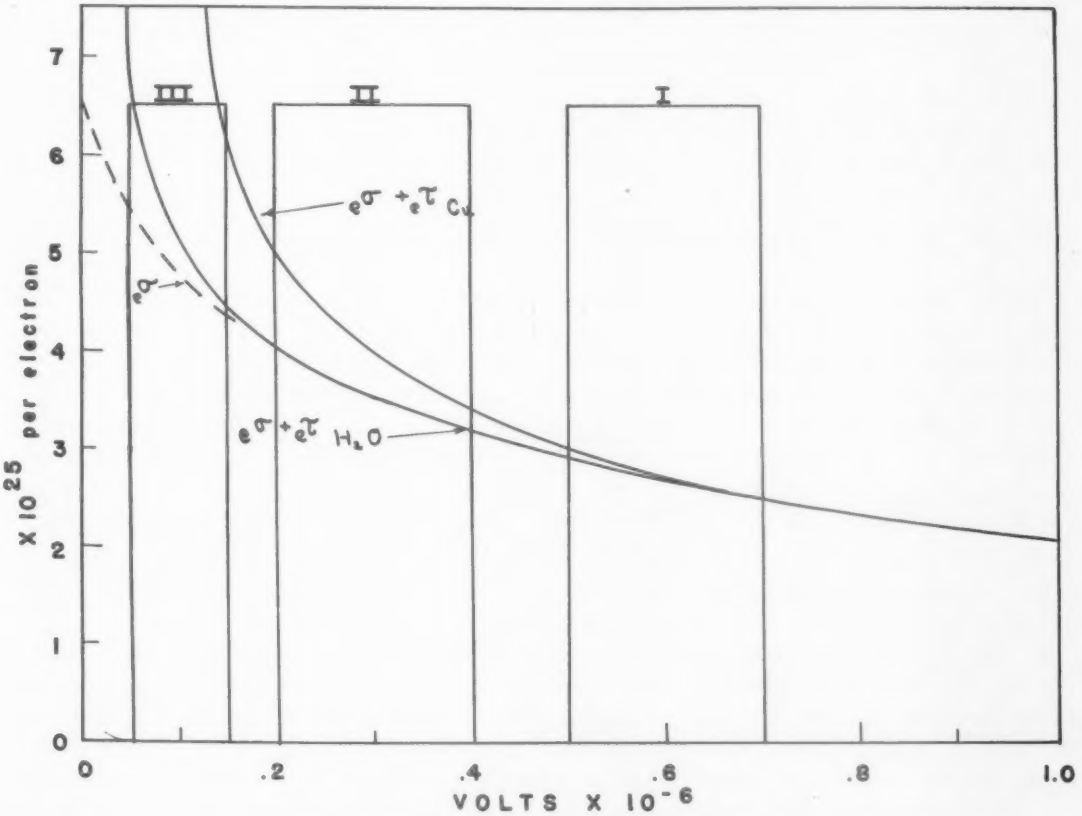

FIG. 1. Simplified case of uniform distribution.

determined is one in which each wave length interval is weighted with its appropriate absorption coefficient, it is evident that two materials for which the shapes of the absorption curves differ greatly may give quite different results for a given beam. For example, let us consider the results obtained in various wave length ranges for the monochromatic equivalent

In Case II, however, the situation is quite different. Here, in the absence of photoelectric absorption, the absorption coefficient in water has the character of the slowly varying Klein-Nishina function, giving an equivalent voltage of about 280 kv. For copper, the photo-effect is not negligible in this region, and its influence is seen in the large curvature of the absorp-

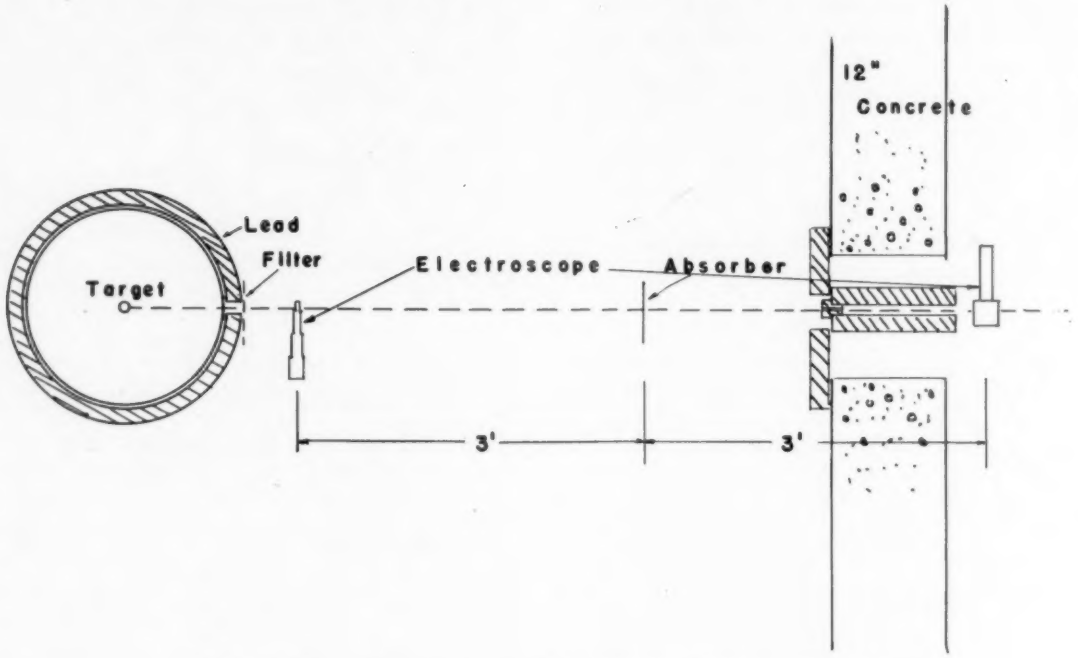

Fig. 2. Geometrical arrangement for half-value layer determinations.

of a given assumed spectral distribution, first in copper and then in water.

We impress, by means of a suitably chosen source of radiation and filter, a continuous distribution in which all wave lengths between certain limits have equal intensity. In Case I (Fig. 1) we have a constant intensity distribution from 500 kv. to 700 kv.; in Case II, from 200 to 400 kv.; and in Case III, from 50 to 100 kv. In all these cases, since the distribution is uniform, the monochromatic equivalent is given simply by the abscissa of the vertical line dividing the area under the absorption coefficient curve into two equal parts.

In Case I, the curves are essentially parallel and hence will give the same monochromatic equivalent, here about 590 kv.

tion curve, giving more weight to the low end of the spectrum, making the monochromatic equivalent about 240 kv.

In Case III, both absorption curves are dominated by the photo-effect and are thus very nearly cubical parabolas. Here again, then, the curves have the same shape and give the same monochromatic equivalent—about 56 kv.

Thus we see that, for the simple case of uniform distribution, the values of the monochromatic equivalent as given by copper and by water at first are equal, then diverge and finally become equal again, as the voltage is increased. This effect might be aggravated in a practical case where the longer wave lengths have relatively more intensity, and hence more

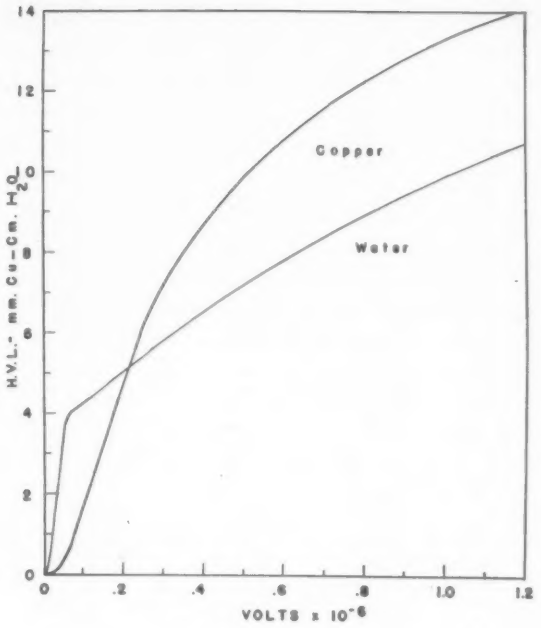

Fig. 3. Calculated half-value layers for monochromatic radiations.

weight. It is also to be remembered that, because the beam is changed in character as it passes through the absorbing material, this treatment is rigorous only for the half-value layer determined by an infinitely thin absorber.

EXPERIMENT

In an effort to determine the applicability of such considerations to the output of an actual tube, half-value layer measurements were made on a 1,000 kv. tube, exicted with nearly sinusoidal alternating current, and provided with a gold target. The prefiltration was 6 mm. of steel.

The geometrical arrangement used is shown in Figure 2. The essential features of this arrangement are (1) great distance from the front chamber to the absorber, to eliminate errors due to the measurement of back-scattered radiation from the absorber, and (2) small solid angle (limited by the lead tunnel and pinhole) subtended by the absorber at the rear chamber, to avoid measurement of the forward scattered radiation. These conditions are vitally necessary to the determination of the absolute monochromatic equivalent of the beam, inasmuch as it is only this case, where the attenuation is governed by the total absorption coefficient, which is amenable both to direct experiment and to rigorous calculation.

Monochromatic equivalents for various half-value layers in copper and water, taken from the calculations of Mayneord[1]

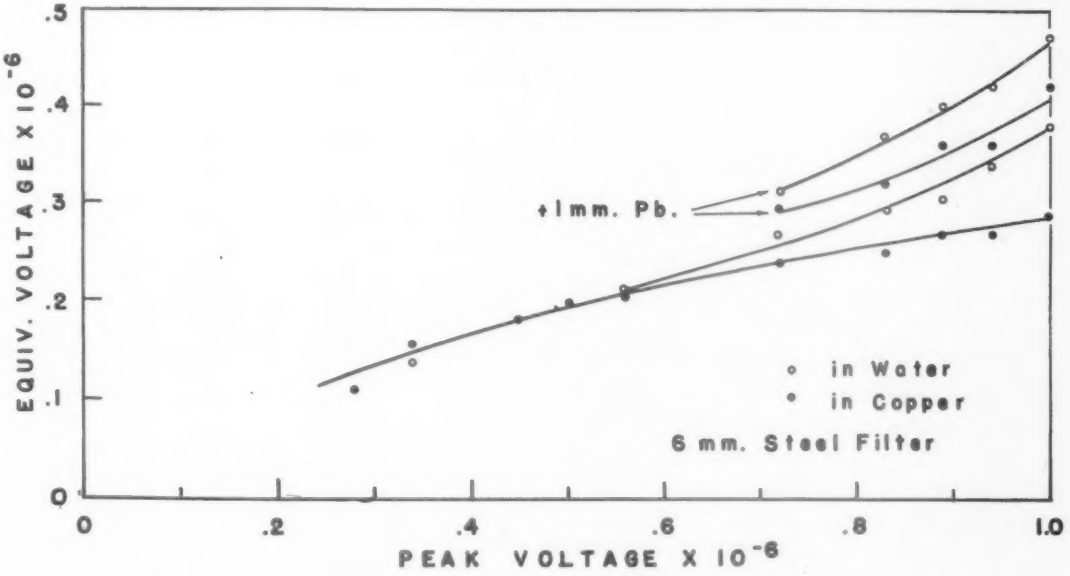

Fig. 4. Monochromatic equivalents determined for various tube voltages.

and of C. C. Lauritsen[2] are plotted in Figure 3.

RESULTS

A comparison of the monochromatic equivalents obtained for copper and presdwood, a pulp product much like water in absorption power, with various filtrations, is shown in Figure 4. It may be seen that at low voltages both materials give essentially the same result, while at the higher voltages the divergence is quite marked. It is also to be noted that the indicated equivalents become more nearly parallel in trend when the low energies are cut out by the addition of 1 mm. lead filtration, suggesting that the curves are converging again.

It is evident, then, that the monochromatic equivalent in copper is not a reliable indication of the behavior of a mixed beam in water or in tissue, and for this reason it seems more logical to adopt water or some water-like substance for comparison of beams used in therapeutic work.

I am very much indebted to Dr. C. C. Lauritsen for much discussion and advice in connection with this problem. Many of the considerations herein contained have already been published by him elsewhere.

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DEPTH DOSE MEASUREMENTS WITH A 1,000 KV. ROENTGEN TUBE

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ABSTRACT

MEASUREMENTS of depth dose at voltages from 100 to 500 kv. monochromatic equivalent, corresponding to tube voltages between 200 and 1,000 kv., are reported. It is found that there is a definite improvement in dose at 10 cm. from 100 to 200 kv. equivalent, but no further increase from 200 to 500 kv., if portals larger than 10×10 cm. are used, while the dose at 5 cm. suffers an actual decrease. It is concluded that, as far as depth dose is concerned, there is no advantage in going to tube voltages higher than 400 kv., unless it is possible to reach voltages much higher than 1,000 kv.

INTRODUCTION

A very important consideration in the discussion of the relative merits of high and low voltage roentgen tubes for deep therapy is necessarily the variation of the depth dose with voltage. It has been known for some time that the improvement in dose at 5 to 10 cm. depth with 200 kv. over that obtained at lower voltages is quite considerable, but only in recent years have experiments shown[1,2] that the rate of improvement drops off quite rapidly at voltages approaching 600 kv., and that the dose at 5 cm. may even show a decrease for large portals. It is the object of the present work to extend these investigations to somewhat higher voltages in an effort to determine whether, in this respect, there is any advantage in the general adoption of extremely high voltage tubes for deep therapy.

EXPERIMENT

The measurements to be reported were made in a Masonite Presdwood phantom, this material being chosen because of its closeness to tissue in density (1.02) and atomic number. To approximate as nearly as possible conditions obtaining in an actual body, a block 30×30×20 cm. was used, irradiated on the largest face. The ionization present at various depths in the block was measured by means of a thimble chamber of about 0.5 cc. volume, containing within it a quartz fiber electrometer (Fig. 1). The sensitivity was adjusted to a convenient value of 10 r full scale by the inclusion of an amber condenser in the wall. Measurements with radium were made with the full sensitivity of 0.025 r full scale.

In the interpretation of the ionization in such a chamber there are several factors to be considered. Measurements in the cavity must be converted to energy absorbed in the medium; the "wall effect" must be investigated; the problem of how much the introduction of the instrument affects the character of the phenomena to be measured must be considered.

With regard to the wall effect and the conversion from ionization in a cavity to ionization in the wall material, L. H. Gray[3] has made an admirable discussion, in which he concludes that the factor of proportionality depends only on the relative electron densities and not at all on wave length. It is essential for the application of this result that the chamber be small compared with the distance in which the primary radiation is appreciably absorbed in air, and small compared with the range of the secondary electrons in air. In the region where photoelectric absorption is important—the situation existing at any considerable depth in the medium—these conditions limit the chamber dimensions to the order of a few millimeters.

In order that the ionization in the wall material so calculated be a measure of the ionization in the surrounding medium, it is sufficient in all wave length regions that

the wall material be of the same atomic number as the medium, or, as a possible alternative that the wall be reduced to zero thickness. Inasmuch as the atomic number of tissue is a somewhat indeterminate quantity, varying greatly from place to place in the body, it would seem that only the extrapolation method, applied to each individual case, can lead to precise results. However, as presdwood has been more or less adopted as the standard material for depth dose measurements, a chamber with walls made of bakelite or amber, being of quite similar composition to presdwood, would be a reasonably close approximation. It is hoped that it will be possible in the near future to make some comparison between very small bakelite chambers and the extrapolation chamber described by Failla.[4]

The question of the amount of change the introduction of a measuring instrument makes in the character of the phenomena to be investigated is always an important one. It is certain that measurements of absorbed energy made close to the surface, or with small beams, with large chambers may be entirely vitiated by the fact that the air space in the chamber scatters and absorbs very differently from the medium which it replaces. In these experiments, the chamber cavity was only 6 mm. in diameter, and was used at depths of 5 and 10 cm., in beams larger than 5×5 cm. The error introduced by this factor is then certainly quite small.

In order to check roughly the fulfillment of the above conditions some of the points were checked with a chamber having only 20 mm.^{3} volume with walls 0.5 mm. thick. In all cases, the relative values agreed within experimental error, although the absolute values were slightly lower. From this it is concluded that the chambers used here give a reasonably accurate indication of energy absorbed even in the range of energies present at considerable depth in the medium.

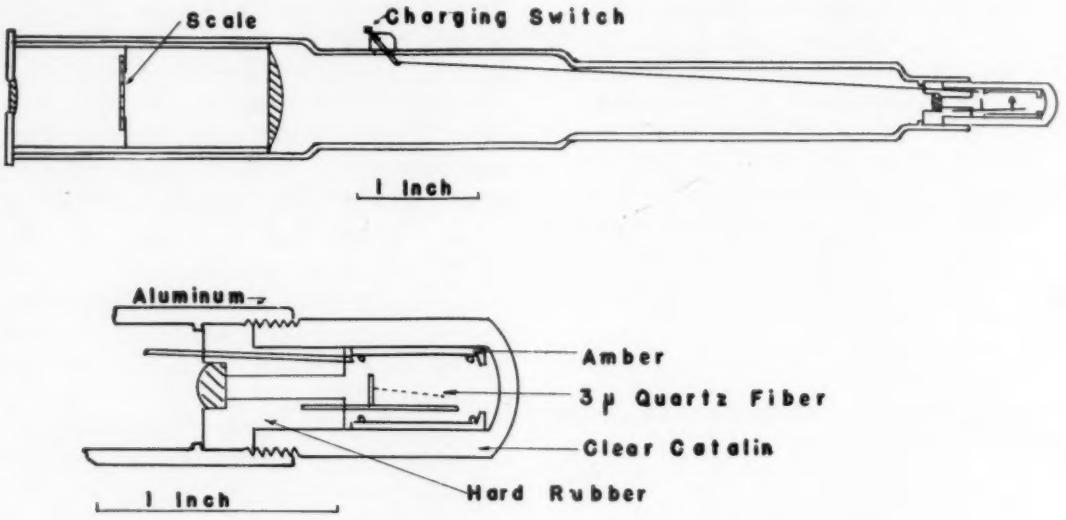

FIG. 1. Construction of combined electrometer and thimble chamber.

To determine the depth dose under given conditions, then, two identical instruments were used, the amount of discharge of one, kept in a fixed position on the surface, being compared with that of the other, placed alternately at the depth and in its appropriate position on the surface. The use of two instruments was necessitated by the difficulty of holding the tube output sufficiently constant during a run. The deflections were so taken that the slight-nonlinearity of the scales did not affect the quotients.

The incident beam was defined by means of a lead diaphragm placed about 20 cm. in front of the phantom. The target-skin distance was in all cases 60 cm.

For an absolute calibration of the tube, half-value layers in presdwood were measured, and the monochromatic equivalent voltages determined from the calculations of C. C. Lauritsen.[5]

RESULTS

The curves obtained for variation of depth dose with equivalent voltage, for three portal sizes and two depths, are shown in Figure 2. The variations plotted are believed to be reliable to about 1 per cent, with an uncertainty in the absolute values of about 2 per cent.

It will be observed that, for portals larger than 11×11 cm., the depth dose shows an actual decrease, particularly at the smaller depth, for equivalent voltages between 200 and 500 kv. Also noteworthy is the fact that the rise for a portal as large as 5×5 cm. is very nearly parallel to the theoretical curve, calculated from the data given by C. C. Lauritsen,[5] on the assumption of no scattering into the measuring volume.

The results are, in the overlapping regions, in quite good agreement with those given by Mayneord and Roberts[1] and by Corrigan.[2]

CONCLUSIONS

From these measurements, it is evident that one must expect to go to voltages much in excess of 1,000 kv. (peak) to obtain any appreciable improvement in depth dose at 10 cm. with large portals over that obtained with 300 to 400 kv. peak (with, of course, suitable filtration).

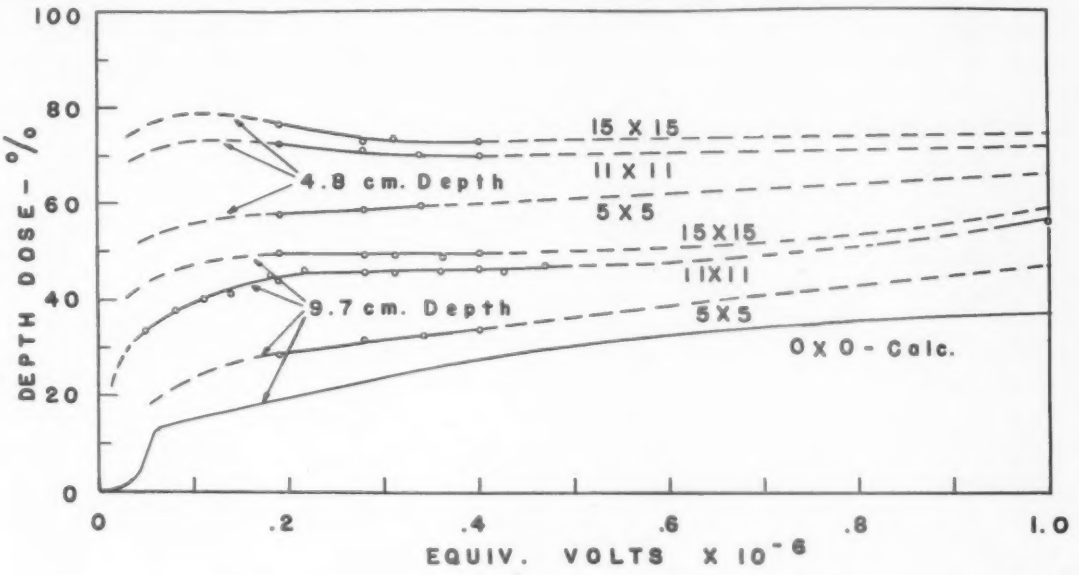

Fig. 2. Variation of depth dose with voltage and portal size.

Qualitatively, the decrease of the depth dose with increasing voltage may be understood when one recalls that depth dose is determined to a large extent by the variation in the true absorption coefficient of the radiation as it is degraded in passing through matter. Consequently, one might expect a maximum in the depth dose where the true absorption coefficient is changing most rapidly, that is, where the ratio of the absorbability of the radiation in the depth to that on the surface is highest, namely at about 100 kv. monochromatic equivalent.

A more detailed consideration of the theoretical aspects of the problem appeared in a paper by C. C. Lauritsen[6] presented at

the Fifth International Congress of Radiology in September, 1937.

My very great thanks are due Dr. C. C. Lauritsen for his continued help and encouragement in the consummation of this work.

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FILING AND CROSS-INDEXING ROENTGEN-RAY RECORDS

DEMONSTRATION OF A SIMPLE AND EFFICIENT METHOD*

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THE desirable practice of currently cross-indexing roentgenological impressions or diagnoses may soon become requisite for all departments of roentgenology which aspire to qualify as approved teaching organizations. The wisdom of this regulation, now under consideration by the American Medical Association and the American Board of Radiology, is self-evident. Accumulated roentgenograms, however fine they may be from a technical viewpoint or however rich in medical interest, are of distinctly limited teaching value unless this tangible fund of clinical experience can be approached in an orderly fashion. Filing and indexing systems which have as their aim the location of roentgenograms and reported findings of individual patients are distinctly limited in value since they provide no assistance in rearranging this material for the purpose of medical study. Only by reviewing past experiences does one learn to appreciate the great variability which exists in the manner by which pathological processes reveal themselves to the roentgenologist. It is unthinkable that any individual can catalog his own personal observations in medicine, if these become at all voluminous, without systematic clerical aid.

Throughout his period of instruction in the clinical divisions, each student of medicine is repeatedly reminded by his teachers that permanent records are of tremendous importance in the care of patients, although he is seldom instructed in methods of cross-indexing medical records by diagnosis for the all-important purpose of self-instruction. The multiplicity of methods employed by hospital record divisions for cataloging case histories suggests that the majority of these are known to be inadequate and the fact that it appears advisable to require some form of cross-indexing in departments of roentgenology implies that, as yet, no method has been presented which is sufficiently practicable to encourage widespread adoption.

Record-keeping constitutes for every department of roentgenology a major problem which is all too frequently underestimated when floor space, specialized equipment and personnel needs are being planned. Not only must such laboratories maintain active office records, as well as filed reports of findings as reported to referring physicians, but in addition, original roentgenograms or copies in miniature must be preserved for future reference. It is quite impossible to anticipate which roentgenograms may prove to be of vital importance to patient or physician at some future date, and this fact necessitates permanent filing of all films exposed. In addition to existing wisely stipulated regulations governing the manner in which films must be stored, it is imperative that film records be made available for ready reference with a minimum of delay and effort.

Although it is not the purpose of this discussion to offer solutions to all of the clerical problems which confront the roentgenologist, it is necessary to emphasize the fact that diagnostic cross-indexing of roentgen findings goes hand in hand with systematic handling of accumulated films. Such indexing is valueless unless cataloged records are readily available when approached in this manner, and availability depends upon trustworthy identification of individual roentgenograms and orderly filing.

It would seem that the necessity for indelibly dating all roentgenograms would

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occur to anyone giving thought to the matter. Roentgenographic evidence does not differ from other forms of clinical information in this respect, and yet in many laboratories films are dated in a careless, uncertain fashion while in some no effort is made to establish the date of examination on the film. The use of non-permanent writing fluids or gummed paper labels is often attended by subsequent effacement of date and other identifying markings, whereas photographic dating or the use of film perforating machines insures against errors of this sort.

For immediate identification with the particular patient represented, marking of roentgenograms with the patient's name has many obvious advantages over the use of an assigned case number, advantages which promptly depreciate, however, when filing is attempted. Every addition to an alphabetical file requires the shift of material since exact positioning depends not only upon the initial of the surname but upon the order of letters which follow. This process may require sorting involving all letters of the entire name and is therefore unwarrantably time-consuming and inefficient. Frequent expansion of component divisions of the file are necessary, involving the relocation of bulky masses of stored film. If case numbers, rather than names are used to determine filing position, growth of the file will be linear rather than by internal expansion.

The basic unit of a roentgen-ray file is the record of an individual patient. It is often advisable to review all of the findings gleaned from previous examinations whenever a patient returns for further study and, to accomplish this with a minimum of effort, the complete film record of every patient should be stored in one portfolio large enough to accept 14″ × 17″ films regardless of number or size of films actually used. Copies of all written reports, if stored in the same portfolio, will be conveniently available whenever a patient's films are reviewed. If this plan is followed, the search of files for any type of information regarding a given patient examined one or a number of times is reduced to a single operation, and the saving in time and labor thus effected is no small item in the overhead cost of a busy laboratory. If the desirable plan of filing records by serial number is adopted, approach to the file by patient's name can be provided by maintaining a name-number index on small filing cards.

Beginning with a well conceived plan of record filing, one more clerical procedure is necessary in order to make accumulated records readily accessible according to reported roentgen findings. This procedure should be planned with the greatest care to eliminate all unnecessary steps, at the same time preserving every essential feature of cross-indexing. If the system of filing described above is followed, accumulated records will consist of a series of portfolios, each identified with an individual patient by means of an assigned case number. Each portfolio will contain all films which have been preserved, an inner envelope containing written consultation requests, copies of roentgenological reports, pertinent correspondence, copies of biopsy reports and operative procedures if available, stapled together in date sequence. There are many advantages to this type of filing which should be very carefully considered before any alternate plan is selected.

In designing the method of cross-indexing to be adopted, it is advisable to consider in advance the probable demands which will be made upon it. Certainly the outstanding use of the index will be to select related case material for the study of some phase of roentgen diagnosis. Studies of this sort may be broad and sweeping in scope or highly restricted to some particularized group of roentgen findings. Investigations based upon recorded experiences as a rule confine themselves to some one disease or to the various diseases which may affect a particular part of the body. The tendency of such investigations to such self-limitation encourages the breakdown of the catalog at the outset into a few major anatomical subdivisions. It is wise to create major subdivisions known by ex-

perience to be of practical significance in the field of diagnostic roentgenology. Even if no further indexing were planned, this primary grouping would reduce to one-tenth the mass of case material to be inspected in most clinical studies. Depending upon his personal experience within his own practice, each roentgenologist can readily determine the number and identity of the initial or main subdivisions which it is desirable to create. At the University of Michigan it has been found advantageous to create ten such major divisions as shown in Table 1.

TABLE I

MAJOR DIVISIONS OF DIAGNOSTIC CODE FOR ROENTGENOLOGICAL FINDINGS

Field	I	Paranasal sinuses
		Mastoids
		Bones of face
		Mandible
Field	II	Skull and brain
Field	III	Vertebral column
Field	IV	Upper extremity bones and joints
Field	V	Lower extremity bones and joints
Field	VI	Chest
		Thoracic wall
		Cervical soft tissues
		Heart and great vessels
		Other mediastinal structures
Field	VII	Chest
		Lungs and pleura
		(Tuberculosis excluded)
Field	VIII	Chest
		Intrathoracic tuberculosis
Field	IX	Gastrointestinal tract
Field	X	Genitourinary tract

Because experience has shown that at this institution one-third of all diagnostic procedures requested by the clinical staff are related to the chest, this large mass of material is initially allocated, as indicated above, to three of the ten major groups. If one wishes to study bronchogenic neoplasm, for example, he need only to consult the material listed under Field VII, at one motion eliminating from consideration case material listed under the remaining nine fields including all tuberculous lesions and chest findings restricted to mediastinal and chest wall structures. It is a well-known fact that the majority of all roentgenological examinations yield negative findings. If then one were to segregate frankly normal situations in each of the ten fields above enumerated, the bulk of material to be searched in isolating roentgenograms reported to show evidence of bronchogenic neoplasm, to continue our example, would have been still further reduced.

It is very important that diagnostic cross-indexing be made as simple as possible. One's first impulse is to develop an index which provides specifically for each and every variant of roentgen appearance that has ever been described. For a number of reasons one should abandon this attitude at the outset. It is frankly impossible to anticipate detailed roentgenological evidences of disease which may at some time in the future become well established and valuable. Since, to repeat, the purpose of the diagnostic cross-index is to simplify the tedious search through voluminous records for material pertinent to some particular study project, it is wise to estimate in advance how far it is practicable to carry the plan. If poor judgment is employed the index is very apt to become unnecessarily detailed, with the ultimate consequence that the effort required to maintain the index overshadows its practical value, and this state of affairs is, of course, intolerable.

If a little thought is devoted to the problem, it is surprising how easily one can subdivide recognizable evidences of disease in any of the major fields listed into a relatively few divisions. The actual selection of these divisions should be made with due consideration to the expected volume which will develop in each, and if this is done one should find that it is not profitable to set up a specific pocket for described evidences of admittedly rare diseases. For example, it is sufficient under each of the fields devoted to skeletal structures to provide a subdivision for primary neoplasm and a second subdivision for metastatic neoplasm. To go farther is entirely unnecessary. Among 2,251 roentgenograms of the upper extremity representing the entire volume in that field at the University

of Michigan for a twelve months' period, primary bone neoplasm was described in 42 reports, metastatic neoplasm in 14. If one contemplated a specific study of giant cell tumor in bone, or perhaps bone metastases from carcinoma of the thyroid, the cross-index would have served remarkably well to narrow the search to these small limits. Undoubtedly one would wish to review all primary neoplasms in the one case or all metastatic neoplasms in the other, rather than to accept blindly the initially recorded roentgenological impressions.

Anyone planning the development of a diagnostic cross-index for his own filed case material will, of course, wish to develop the code to be used in the segregation process according to his own experiences and his own anticipated desires in the matter of subsequent use. At the University of Michigan a coding plan representing the outgrowth of several previous schemes developed here and elsewhere was formulated and put into service July 1, 1934. At the end of one year, several serious errors which had come to light were corrected and the coding plan, revised as of July 1, 1935, has since been in use without further alteration. In this Department of Roentgenology, large patient volume, together with the fact that the hospital record division maintains a tabulating bureau, has encouraged the employment of mechanical punch cards in maintaining the diagnostic cross-index. Physicians trained in roentgenology in this institution have frequently expressed the desire that some system be devised to permit use of this coding plan in their own practices. To comply with this request, which requires the elimination of punch cards since their use can only be justified when volume is great, the coding plan has been modified in several minor details in order to permit simple manual scoring upon prepared loose-leaf notebook sheets. At the same time the code has been altered to more adequately meet the requirements of smaller laboratories. The indexing code in its present form consists of two principal divisions: the first deals with normal roentgenological findings, subdivided within fields to permit the specification of anatomical structures; the second with abnormal findings of all sorts (Table II).

TABLE II

DETAILED CODE FOR NORMAL FINDINGS

Field I	a—Paranasal sinuses
	b—Mastoids
	c—Bones of face
	d—Mandible
Field II	a—Skull
	b—Physiological calcifications
	c—Encephalogram
	d—Ventriculogram
Field III	a—Cervical spine
	b—Thoracic spine
	c—Lumbar spine
	d—Sacrococcygeal spine
	e—Myelogram
Field IV	a—Pectoral girdle
	b—Humerus
	c—Radius
	d—Ulna
	e—Bones of hand
	f—Acromioclavicular joint
	g—Shoulder joint
	h—Elbow joint
	i—Joints of wrist and hand
Field V	a—Pelvis
	b—Femur
	c—Tibia
	d—Fibula
	e—Bones of foot
	f—Sacroiliac joint
	g—Hip joint
	h—Knee joint
	i—Joints of ankle and foot
Field VI	a—Chest
Field VII	b—Thoracic wall
(combined)	c—Heart examination
	d—Bronchogram
	e—Cervical soft tissues
Field IX	a—Upper gastrointestinal tract
	b—Colon
	c—Scout film abdomen
Field X	a—Regular KUB
	b—Retrograde pyelogram
	c—Excretory pyelogram
	d—Urethrocystogram
	e—Pelvimetry
	f—Uterogram

The code of normal findings is subdivided into Fields I to X, exclusive of VIII. Field VIII, it will be remembered is reserved specifically for roentgen findings judged to be characteristic of intrathoracic tuberculosis which at once precludes the

provision of a corresponding normal section. Examinations of the chest failing to show signs typical of pulmonary tuberculosis will be indexed as normals under combined Fields VI and VII. Lower case letters are employed to designate anatomical subdivisions within fields. To make use of the code for normal findings, one merely adds at the end of his original report the notation IV-b, to indicate, for example, that examination of the humerus for suspected fracture shows no indication of abnormality. The necessity for qualifying subdivisions of normal findings is greatest in Fields IV and V, where identification of numerous bones and joints renders nine sections desirable.

In the case of abnormal findings it is wise to subdivide more elaborately and to this end each field has been provided with 30 classifying subsections (Table III).

TABLE III

INDEXING CODE FOR ABNORMAL ROENTGEN FINDINGS

FIELD I: SINUSES, MASTOIDS, BONES OF FACE, MANDIBLE

SINUSES
1. Clouding
2. Thickened mucous membrane
3. Polyp, mucocele
4. Neoplasm
5. Osteomyelitis

MASTOIDS
6. Clouding
7. Thickened cell walls
8. Sclerosis
9. Bone destruction
10. Cholesteatoma
11. Temporomandibular joints: Normal and abnormal

BONES OF FACE (INCLUDING ORBIT)
12. Fracture, dislocation
13. Osteomyelitis
14. Neoplasm
15. Foreign body in orbit
16. No foreign body in orbit
17. Optic foramina: Normal and abnormal

MANDIBLE
18. Fracture, dislocation
19. Osteomyelitis
20. Neoplasm (include cysts)
21. Dental abnormality
26. ANOMALY
27. POSTOPERATIVE
28. SINUS TRACT INJECTION
29. EXCEPT AS ABOVE
30. UNSATISFACTORY EXAMINATION

LOCALIZATION
A = Sinuses
B = Mastoids
C = Bones of face
D = Mandible
? = Diagnosis indeterminate
* = Special interest

FIELD II: SKULL

1. Anomaly
2. Fracture, depressed
3. Fracture, other than depressed
4. Inflammatory disease of skull bones
5. Neoplasm, primary
6. Neoplasm, secondary
7. Benign hyperostosis
8. "Heterosteonosus"

EVIDENCE OF INTRACRANIAL LESION
9. Sutural changes
10. Accentuated digital markings
11. Intrasellar erosion
12. Extrasellar erosion
13. Parasellar erosion
14. Local bone changes: Destructive or proliferative
15. Displaced physiologic calcification
16. Abnormal intracranial calcification
17. Unusual vascular markings suggesting intracranial lesion
18. Brain atrophy, hypoplasia, porencephaly, anomaly
19. Obliteration of sulci and cisterns
20. Traction displacement or deformity of ventricular system
21. Internal hydrocephalus
22. Tumor intracranial: supratentorial
23. Tumor intracranial: infratentorial
24. Tumor intracranial: unspecified
25. ROENTGENOLOGICALLY IDENTIFIABLE TUMOR TYPE
27. POSTOPERATIVE
28. SINUS TRACT INJECTION
29. EXCEPT AS ABOVE
30. UNSATISFACTORY EXAMINATION

LOCALIZATION
A = Skull
C = Encephalogram
D = Ventriculogram
? = Diagnosis indeterminate
* = Special interest

TABLE III—*Continued*

FIELD III: SPINE

1. Abnormal curvature
2. Postural back
3. Reduced joint space, lumbosacral area
4. Spondylolisthesis
5. Arthritis, hypertrophic
6. Arthritis, atrophic
7. Intervertebral disc change
8. Soft tissue lesion; paravertebral abscess
9. Dislocation, subluxation
10. Fracture
11. Osteochondritis (epiphysitis)
12. Tuberculosis
13. Non-tuberculous inflammatory disease
14. Neoplasm, primary
15. Neoplasm, secondary
16. Trophic change
17. Paget's disease; osteitis fibrosa cystica
18. "Heterosteonosus"
19. Myelogram, abnormal

26. ANOMALY
27. POSTOPERATIVE
28. SINUS TRACT INJECTION
29. EXCEPT AS ABOVE
30. UNSATISFACTORY EXAMINATION

LOCALIZATION

A = Cervical spine
B = Dorsal spine
C = Lumbar spine
D = Sacrococcygeal spine
? = Diagnosis indeterminate
* = Special interest

FIELD IV: UPPER EXTREMITY

1. Soft tissue lesion
2. Fracture
3. Fracture: healing or healed
4. Fracture: non-union or malunion
5. Slipped epiphysis; epiphyseal separation
6. Dislocation, subluxation
7. Tuberculosis: bone or joint
8. Osteomyelitis
9. Other inflammatory disease
10. Osteochondritis, loose body, osteochondritis dissecans
11. Trophic change
12. Rickets, scurvy
13. "Heterosteonosus"
14. Arthritis, atrophic
15. Arthritis, hypertrophic
16. Arthritis, mixed
17. Arthritis, traumatic
18. Arthritis, septic, purulent, gonococcal
19. Arthritis, metabolic: gout, hemophilia, etc.
20. Arthritis, except as above
21. Ankylosis
22. Deformity
23. Neoplasm, primary
24. Neoplasm, secondary

26. ANOMALY
27. POSTOPERATIVE
28. SINUS TRACT INJECTION
29. EXCEPT AS ABOVE
30. UNSATISFACTORY EXAMINATION

LOCALIZATION

A = Pectoral girdle
B = Humerus
C = Radius
D = Ulna
E = Bones of hand
F = Acromioclavicular joint
G = Shoulder joint
H = Elbow joint
I = Wrist and hand joints
? = Diagnosis indeterminate
* = Special interest

FIELD V: LOWER EXTREMITY

1. Soft tissue lesion
2. Fracture
3. Fracture: healing or healed
4. Fracture: Non-union or malunion
5. Slipped epiphysis; epiphyseal separation
6. Dislocation, subluxation
7. Tuberculosis: bone or joint
8. Osteomyelitis
9. Other inflammatory disease
10. Osteochondritis, loose body, osteochondritis dissecans
11. Trophic change
12. Rickets, scurvy
13. "Heterosteonosus"
14. Arthritis, atrophic
15. Arthritis, hypertrophic
16. Arthritis, mixed
17. Arthritis, traumatic
18. Arthritis, septic, purulent, gonococcal
19. Arthritis, metabolic: gout, hemophilia, etc.
20. Arthritis, except as above
21. Ankylosis
22. Deformity
23. Neoplasm, primary
24. Neoplasm, secondary

26. ANOMALY
27. POSTOPERATIVE
28. SINUS TRACT INJECTION
29. EXCEPT AS ABOVE
30. UNSATISFACTORY EXAMINATION

TABLE III—*Continued*

LOCALIZATION

A = Pelvis
B = Femur
C = Tibia
D = Fibula
E = Bones of foot
F = Sacroiliac joint
G = Hip joint
H = Knee joint
I = Ankle and foot joints
? = Diagnosis indeterminate
* = Special interest

FIELD VI: THORACIC WALL, MEDIASTINUM, SOFT TISSUES OF NECK, CARDIOVASCULAR SYSTEM

THORACIC WALL

1. Anomaly
2. Soft tissue lesion; interstitial emphysema
3. Fracture: rib, sternum
4. Inflammatory disease
5. Neoplasm: primary or secondary
6. Postoperative
7. Except as above: thoracic wall
8. Abnormal diaphragm: except as listed in Fields VIII and IX

MEDIASTINUM, SOFT TISSUES OF NECK

9. Abnormal cervical thyroid
10. Substernal thyroid
11. Soft tissues of neck: other abnormalities
12. Abnormal thymus
13. Mediastinitis; non-tuberculous inflammatory adenopathy
14. Lymphoblastoma: mediastinum and hila
15. Neoplasm, primary
16. Neoplasm, secondary
17. Except as above: mediastinum, soft tissues of neck

CARDIOVASCULAR SYSTEM

18. Congenital heart disease
19. Cardiac enlargement
20. Mitral stenosis: roentgen signs
21. Pericarditis; pericardial effusion
22. Tortuous, elongated aorta
23. Aneurysm
24. Calcification: heart, pericardium, aorta
25. Calcification: peripheral vessels
26. Pulmonary congestion, edema
27. Except as above: cardiovascular

28. SINUS TRACT INJECTION
30. UNSATISFACTORY EXAMINATION
? = Diagnosis indeterminate
* = Special interest

FIELD VII: LUNGS AND PLEURA

1. Foreign body
2. Pleuritis without effusion
3. Pleural effusion, empyema
4. Hydropneumothorax
5. Pneumothorax: spontaneous, induced, traumatic
6. Pneumonia, lobar
7. Pneumonia, resolving or resolved
8. Pneumonia, unresolved
9. Pneumonia, except as above
10. Bronchiectasis, suspected
11. Bronchiectasis, proved by previous bronchogram
12. Abnormal bronchogram: bronchiectasis
13. Abnormal bronchogram: other than bronchiectasis
14. Pneumonitis, suppurative
15. Pneumonitis, except as above
16. Abscess, cyst
17. Infarct
18. Atelectasis
19. Pulmonary emphysema
20. Pneumoconiosis
21. Radiation fibrosis
22. Neoplasm, primary
23. Neoplasm, secondary
24. Lymphoblastoma, lung parenchyma
25. Tuberculosis: DIFFERENTIAL DIAGNOSIS ONLY

26. ANOMALY
27. POSTOPERATIVE
28. SINUS TRACT INJECTION
29. EXCEPT AS ABOVE
30. UNSATISFACTORY EXAMINATION
? = Diagnosis indeterminate
* = Special interest

FIELD VIII: INTRATHORACIC TUBERCULOSIS

1. Calcium deposit, parenchyma
2. Calcium deposit, lymphnodes
3. Tuberculous, non-calcified parenchymal lesion (child)
4. Enlarged lymph nodes, tuberculous
5. Tuberculosis suspect: existence of lesion questionable
6. Inactive, non-calcified tuberculous lesion
7. Minimal tuberculosis
8. Moderately advanced tuberculosis
9. Far advanced tuberculosis
10. Miliary tuberculosis
11. Cavity, suspected
12. Cavity
13. Pleuritis without effusion
14. Pleural effusion, empyema
15. Calcium deposit pleura
16. Viscero-parietal pleural adhesions
17. Spontaneous pneumothorax
18. Reactivation, spread

TABLE III—*Continued*

19. Pneumothorax, induced
20. Phrenic interruption
21. Pneumolysis, any type
22. Thoracoplasty
23. Other surgical procedures
28. SINUS TRACT INJECTION
29. EXCEPT AS ABOVE

B = Bilateral (for use with diagnoses 7, 8, and 9)
* = Special interest

FIELD IX: GASTROINTESTINAL TRACT

ESOPHAGUS
1. Cardiospasm
2. Diverticulum
3. Neoplasm
4. Foreign body

STOMACH AND SMALL BOWEL
5. Diverticulum
6. Ulcer: gastric
7. Ulcer: duodenal
8. Ulcer: other than above
9. Neoplasm
10. Obstruction: gastric outlet

BILIARY TRACT
11. Cholecystogram, normal visualization
12. Cholecystogram, faint visualization
13. Cholecystogram, non visualization
14. Biliary stone
15. Abnormal liver shadow

COLON
16. Diverticulosis, diverticulitis
17. Colitis: ulcerative, tuberculous, etc.
18. Neoplasm

ABDOMEN GENERALLY
19. Calcification abdomen
20. Extra-alimentary mass
21. Intestinal obstruction
22. Subphrenic abscess; free peritoneal air
23. Diaphragmatic hernia, eventration, congenital defect diaphragm.
24. FISTULA
25. INTRINSIC LESION, ? IDENTITY
26. ANOMALY
27. POSTOPERATIVE
28. SINUS TRACT INJECTION
29. EXCEPT AS ABOVE
30. UNSATISFACTORY EXAMINATION

? = Diagnosis indeterminate
* = Special interest

LOCALIZATION

E = Esophagus C = Colon
S = Stomach B = Biliary tract
I = Small bowel A = Abdomen general

FIELD X: GENITOURINARY TRACT

1. Incomplete filling—pyelogram

KIDNEY, URETER
2. Absence kidney
3. Enlargement kidney
4. Displacement, rotation of kidney
5. Anomaly
6. Calculus, renal
7. Calculus, ureteral
8. Hydronephrosis
9. Hydroureter
10. Pyelonephritis, pyonephrosis
11. Tuberculosis: renal, ureteral
12. Intrarenal mass: tumor, carbuncle, cyst
13. Extrarenal mass
14. Pyelovenous, lymphatic backflow
15. Except as above: kidney, ureter

BLADDER, PROSTATE, URETHRA
16. Calculus: bladder, prostate, urethra
17. Contracted, trabeculated bladder
18. Diverticulum
19. Hypertrophy prostate
20. Neoplasm bladder
21. Except as above: bladder, prostate, urethra

FEMALE GENITAL ORGANS
22. Abnormal pelvimetric examination
23. Abnormal uterogram
24. Pregnant uterus
25. Except as above: female genitalia

27. POSTOPERATIVE
28. SINUS TRACT INJECTION
30. UNSATISFACTORY EXAMINATION

? = Diagnosis indeterminate
* = Special interest

Within each field observed findings are identified by sub-numbers while capital letters are used to further specify anatomical location. The addition of a question mark signifies uncertainty regarding reported diagnoses and spectacular findings are emphasized by the additional scoring of an asterisk.

Examination of this code will reveal that in some cases specific, highly restricted roentgen signs of abnormality have been assigned identifying rubrics while in others one subdivision is arranged to accept several related but individually different findings. For instance, in Field VII subdivision "12" is reserved for the single entity "bronchographic evidence of bronchiectasis," while in "13" are grouped all

other bronchographic abnormalities. This plan is purposeful for here as elsewhere the predominant abnormality to be expected is automatically segregated from other less common findings.

With few exceptions catagories common to all fields have been assigned similar access numbers for the sake of simplicity. Recognized developmental anomalies are indicated as No. 26 except where specifically provided for in field sub-sections. Postoperative findings are listed throughout the code under No. 27 except in the intrathoracic tuberculosis field where the nature of the surgical procedure is specified. Throughout all fields, No. 28 indicates observations related to the opaque injection of sinus tracts. In Fields VI and X provision is made for miscellaneous findings within each anatomical section; in all other fields No. 29 represents "except as above." Even though a roentgenological examination may be for one reason or another diagnostically unsatisfactory this fact should be cataloged under No. 30. Since Field VIII has been reserved for demonstrable roentgen signs of pulmonary tuberculosis, there is obviously no need for No. 30 in this particular field.

In the fields reserved for abnormal skeletal findings, II, III, IV and V, the subtitle "heterosteonosus" will be found and questioned. This coined term, meaning literally "dissimilar disease of bone," has proved valuable as an indicator for a heterogeneous group of poorly understood skeletal abnormalities. Hyperparathyroidism, fragilitas osseum and diseases of this sort are well accommodated under this heading. Paget's disease and osteitis fibrosa cystica are given a specific designating number in Field III because they are not too uncommonly encountered in the spine, but in other locations they, too, are coded under "heterosteonosus."

Great care must be used in building whatever code is to be used. With its ultimate purpose always in mind, the code should be constructed to meet any situation which may be encountered in diagnostic roentgenology. Specific provision for each and every diagnostic detail is neither necessary nor wise and "except as above" listings will be found very useful in most emergencies. The asterisk for "special interest," when used in addition, will earmark findings of spectacular character. The aim of coding is to provide effortless presorting of material into relatively small and, therefore, workable groups of cases. To be really valuable a diagnostic index must be employed faithfully in recording the results of each and every roentgenologic examination. This is rendered simple and practicable if each written report carries at the end terse summarizing statements which include all findings to be cross-indexed. Reports which are so prepared are easily read, and coding of final impressions or opinions can be done by the reporter with very little effort. Each summarizing statement is simply reduced to the corresponding code characters which are then recorded at the bottom of the report on the retained copy only (Fig. 1).

The brief review of reported findings necessitated by the act of coding serves to call attention to possible errors or omissions at a time when they are readily correctable. At the end of the day coded statements on all cases reported are quickly recorded in the pages of the cross-index by hand scoring. A loose-leaf notebook containing eight green pages for indexing normal findings and ten red pages for abnormal findings represents the cross-index in its final form. Sample index page forms are reproduced in Figures 2 and 3.* One of these sample pages has been appropriately designated for normal upper extremity findings, Field IV. The other for abnormal findings in lung and pleura, Field VII. The coded statements regarding pleural effusion and the appearance of the wrist (Fig. 1) have been properly scored on these pages.

To make actual use of the plan which has been described, one should adopt the coding plan as given, or modified to suit individual needs or taste, score all reported findings normal or abnormal according to

* These form pages may be obtained from Edwards Bros, Inc, Ann Arbor, Michigan.

UNIVERSITY OF MICHIGAN
UNIVERSITY HOSPITAL
DEPARTMENT OF ROENTGENOLOGY

CONSULTATION REPORT

Name Smith, John Sex M. Age 41 Service Medicine Division O.P.
Registration No. 1000 Referred By Dr. Jones

March 15, 1939

Chest stereo, examination of right wrist

Provisional diagnosis: Lobar pneumonia, left. Pain and stiffness right wrist.

Chest films show extensive loss of transparency, left chest, with complete obliteration of diaphragm contour. Intercostal spaces widened. Abnormal density extends to apex of chest and is very marked along the axilla. Mediastinal structures deviated somewhat toward the right.

Bones, joint surfaces, and soft tissues of right wrist appear normal.

IMPRESSION: 1. Massive pleural effusion, left.

2. Normal wrist joint, right.

A. B. Smith, M.D.

VII-3
IV-i

SAMPLE

16-207001-2-38-07M-228383

FIG. 1. Sample report of roentgenological findings showing use of indexing code.

that code, bind together in loose-leaf form ruled normal and abnormal pages for each field,† and score coded statements in the index-book as indicated by patient number. The index-book may represent a unit of time, as for instance a month or a year, or a unit of volume such as 1,000 patient visits, new books being started as units are completed. The loose-leaf form permits the addition of pages in various fields as they become filled. The following ten examples of coding and scoring are presented to demonstrate the technique of indexing according to this plan. Impressions regarding observed abnormalities, in each of ten patients examined, are listed in Table IV together with corresponding code designations derived from Table III.

In Figure 4 portions of index pages for Fields II, V, VII, VIII, and IX have been reproduced showing how coded findings are

† A single sheet is used for *all* normal chest findings.

scored. Capital letters are substituted for simple check marks only when specific anatomical localization is important.

The plan described provides a cross-index of diagnostic material complete to the close of each day's work. Total incidence figures are immediately available by simple column count for findings in any subdivision and this figure may then be expressed directly in terms of percentage relationship to total voluem. Patient number lists may be quickly obtained to direct recovery of original films and reports from files for review. Cataloging is neither complicated nor laborious and no mechanical

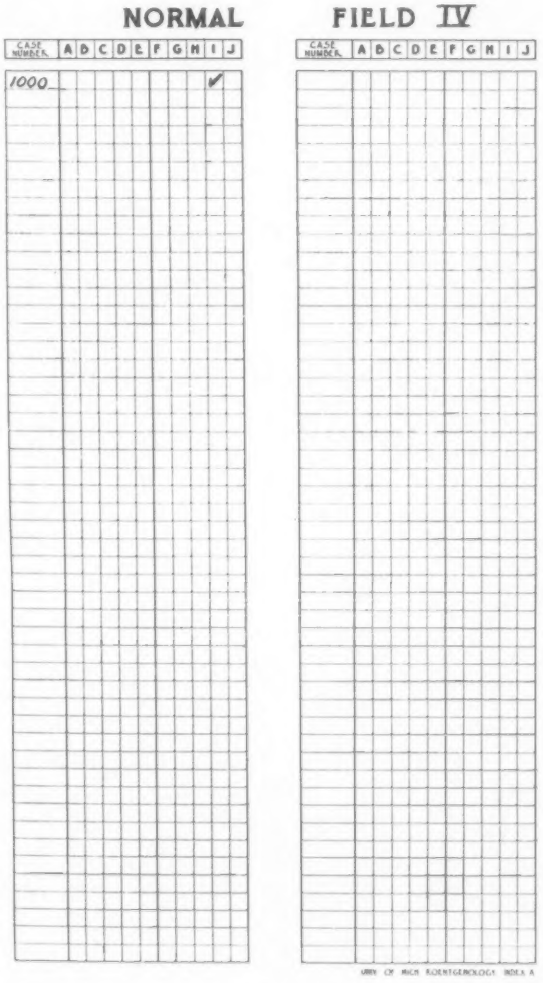

Fig. 2. Reproduction of standard notebook page for the indexing of normal findings. In this figure the page has been prepared for findings restricted to the upper extremity. In the original this form is printed on green paper.

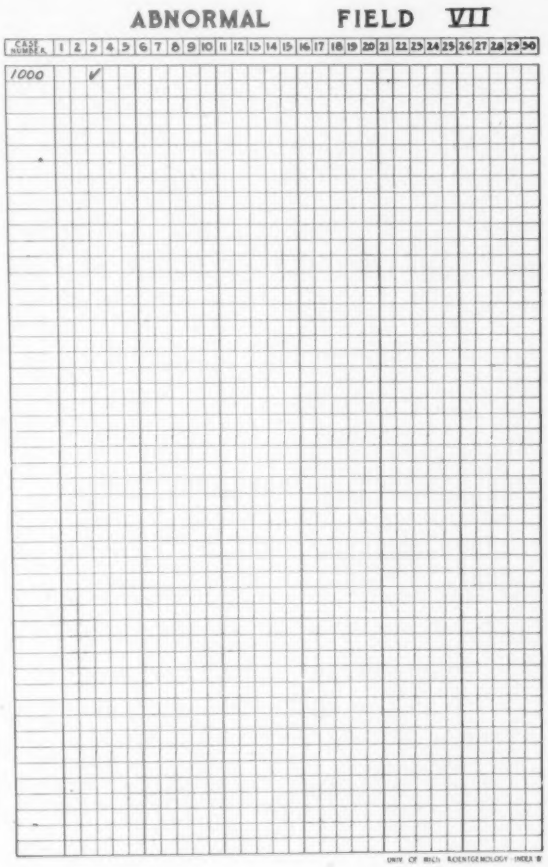

Fig. 3. Standard form for abnormal findings comparable to that reproduced in Figure 2. In the original this is printed upon salmon-pink stock. In this illustration the form page has been numbered "VII" for non-tuberculous abnormalities of lungs and pleura.

tabulating equipment is required, although final results are in many particulars comparable to those obtainable with punch-card apparatus.

Table IV

Case 1001

IMPRESSION: 1. Septic arthritis of left hip.
2. Pulmonary abscess, right lower lobe.

V-18; G
VII-16

Case 1002

IMPRESSION: 1. Hypertrophic arthritis of both sacroiliac joints, right knee and ankle.
2. Healed fracture of right femur.
3. Questionable evidence of depressed skull fracture.

V-15; F, H, I
V- 3; B
II- 2?

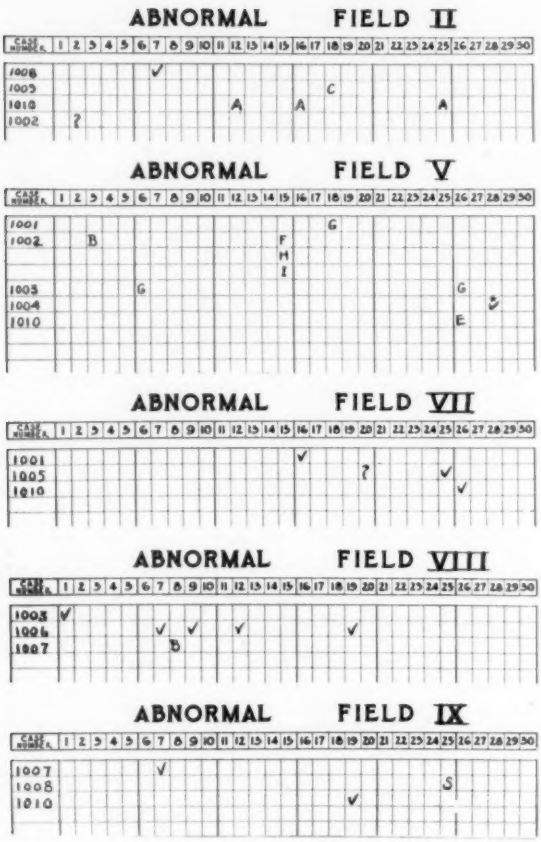

FIG. 4. Samples of indexing forms for abnormal findings prepared for various diagnostic fields. Coding examples listed in Table IV have been scored here to demonstrate the final step in diagnostic cross-indexing.

TABLE IV—*Continued*

Case 1003

IMPRESSION: 1. Congenital dislocation of both hips.
2. Ghon's tubercle, left lung.
V-6, 26; G
VIII-1

Case 1004

IMPRESSION: 1. Sinus tract (visualized by lipiodol injection) extending from the region of the left popliteal fossa to the upper part of the thigh.
V-28*

Case 1005

IMPRESSION: 1. Extensive bilateral pulmonary disease; pneumoconiosis or tuberculosis to be considered.
VII-20?; 25

Case 1006

IMPRESSION: 1. Mimimal pulmonary tuberculosis, right; far-advanced tuberculosis, left, with cavity in apex; induced pneumothorax, left.
VIII-7, 9, 12, 19

Case 1007

IMPRESSION: 1. Bilateral moderately advanced pulmonary tuberculosis.
2. Duodenal ulcer.
VIII-8; B
IX-7

Case 1008

IMPRESSION: 1. Intrinsic lesion of cardia of stomach, identity unknown.
2. Benign hyperostosis of skull.
IX-25; S
II-7

Case 1009

IMPRESSION: 1. Marked atrophy of brain with porencephalic cyst (encephalogram).
II-18; C

Case 1010

IMPRESSION: 1. Calcified tumor in suprasellar region, producing extrasellar erosion; craniopharyngioma.
2. Supernumerary toes, left foot.
3. Azygos lobe.
4. Calcified lymph nodes, right lower quadrant of abdomen.
II-12, 16, 25; A
V-26; E
VII-26
IX-19

The order of writing coded statements as shown insures simplicity and accuracy. The field number in Roman numerals is followed in turn by a hyphen and diagnostic subdivisions in arabic numerals separated by commas and followed by a semicolon. Further anatomical designations are written last in capital letters again separated by commas.

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Twenty-fifth Annual Meeting: New York City, 1940.

EDITORIALS

HARVEY CUSHING AND ROENTGENOLOGY

ON APRIL 8, 1939, Harvey Cushing celebrated his seventieth birthday. It seems difficult to realize that this vital force in world medicine has reached the psalmist's threescore years and ten, and the JOURNAL takes this opportunity of joining with many others who have sent him congratulations and offered their thanks for the contribution he has made, and is still making to the science, as well as to the art, of Medicine. It fell to the Harvey Cushing Society, which held its Eighth Annual Meeting on April 6 to 8, to arrange his birthday party. They were memorable days with a program of interesting papers culminating on Saturday night, April 8, in a birthday dinner at which there were presented as surprises to Dr. Cushing a Scandinavian *festskrift* containing twenty-five papers published in a special number of *Acta chirurgica Scandinavica*;[1] a special number of the *British Journal of Surgery* with a long paper by Mr. William Henderson[2] describing the surgical end-results of Dr. Cushing's 338 cases of pituitary tumors; and an annotated bibliography of all of Dr. Cushing's writings, published for the Society by Charles C Thomas.[3] In addition, the papers read at the birthday meeting have appeared in a special number of the *Yale Journal of Biology and Medicine*, and a brochure is also to be printed containing selections from the speeches and 500-odd letters and telegrams received at the time of his birthday.

[1] A festskrift for Dr. Harvey Cushing edited by Herbert Olivecrona. Issued as a special number of *Acta chir. Scandinav.*, 1939, *82*, 99–363.

[2] Henderson, W. The pituitary adenomata. A follow-up study of surgical results in 338 cases (Dr. Harvey Cushing's series). *Brit. J. Surg.*, 1939, *26*, 809–921.

[3] A Bibliography of the Writings of Harvey Cushing Prepared on the Occasion of his Seventieth Birthday, April 8, 1939, by the Harvey Cushing Society. Charles C Thomas, Springfield, Ill., 1939.

In adding our congratulations we feel that a message from American roentgenologists is highly appropriate, for in Dr. Cushing's first published work, a preliminary report issued in the *Johns Hopkins Hospital Bulletin* in the August-September number of 1897 (vol. 8, pp. 195–196), reference is made to the first roentgenograms ever taken in Boston—of a bullet lodged in the cervical region of the spinal cord. The paper was published in full the following year under the title "Haematomyelia from gunshot wounds of the spine. A report of two cases, with recovery following symptoms of hemilesion of the cord."[4] Dr. Cushing's early association with roentgenology was described some years ago in a discussion of a paper by Sosman and Putnam,[5] published in these columns, and we take this opportunity of reprinting his remarks.

It was, I think, in the spring of 1896 when I was a house officer at the Massachusetts General Hospital that Dr. J. C. Warren, then professor of surgery in the Harvard Medical School, came back from Roentgen's laboratory and showed us a shadow picture of the human hand in which the outlines of the bones were apparent. He showed us, too, a mysterious glass tube about as big as an orange with which the picture had been taken. It of course aroused the greatest possible interest. E. A. Codman and I with the help of Walter Dodd, the hospital pharmacist, who knew something about photography, immediately began to see what we could do in the way of getting similar pictures. This, I suppose, is nothing more than what happened in many other parts of the country at about this time.

It was in that fall of 1896 that I went to Johns Hopkins and made the first roentgenograms that were taken there, with the aid of a

[4] *Am. J. M. Sc.*, 1898, *115*, 654–683.

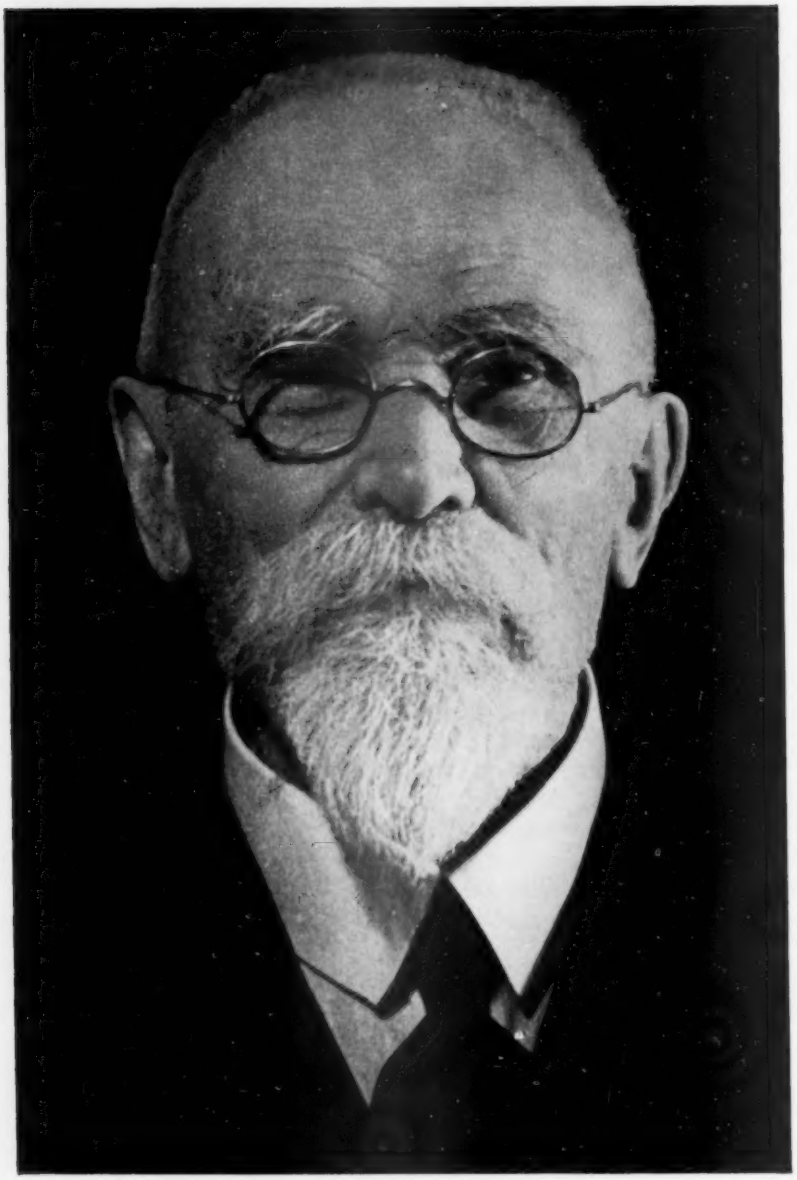
[5] AM. J. ROENTGENOL. & RAD. THERAPY, 1925, *13*, 1–12.

decrepit and perverse static machine as big as a hurdy-gurdy and operated in the same way, by turning a crank. My first paper submitted for publication contained an account of a case of gunshot wound of the spine with plates showing a bullet which a Baltimorean had planted in the body of his wife's sixth cervical vertebra. I once showed these pictures to Dr. Cole and he expressed himself as astonished that such good plates of a spine could have been taken in 1896; but I do not know whether I told him, as I shall now confide to you, that the plates were the result of exposures averaging 35 minutes. And I may add that the pictures which were reproduced were not those of a single experience, for I think the patient was given as many as half a dozen sessions at least, before plates were secured which were sufficiently good for reproduction. Needless to say, she was a most cooperative patient.

Subsequently a Willyoung coil was purchased which I think had a spark gap of 2 or 3 inches. With this coil and the aid of many bottles of rodinol (I do not know whether rodinol is anything more than a memory for the few grey heads in this audience), I spent many weary hours for the next year or two in an improvised dark room off from the old amphitheatre at the Johns Hopkins Hospital developing roentgen-ray plates in which no one at the time took any very great interest. Certainly none of us could have had any possible conception of the increasingly important rôle the roentgen-ray was to play in clinical diagnosis and treatment.

But when we think of Harvey Cushing we think not only of roentgenology, of the special field of brain surgery which he created, or of the Riva-Rocci pneumatic cuff which he brought to the United States in 1901, thus inaugurating the clinical study of blood pressure in this country, but we think of much else. Cushing's "Life of Sir William Osler," Cushing's extraordinary capacity to handle patients of all walks of life, his series of brilliant surgical monographs—the last on the meningiomas being a model of vigorous writing and painstaking illustration—and, finally, those who have had the privilege of knowing him more intimately think of his extraordinary library to which he is still adding; among other things it includes the most complete collection of Andreas Vesalius ever to be brought together. His library is probably the greatest medical collection now in private hands.

We trust that Harvey Cushing may long be spared to work in his library, that he may complete his bibliography of Vesalius and that he may continue to give us for many years to come the rich and varied inspiration of his great example.



ANTOINE BÉCLÈRE
1856—1939

THE death of Antoine Béclère on February 24, 1939, brought to a close the earthly career of one of the most colorful, universally beloved and esteemed of all the world's radiologists. As an honorary member of the American Roentgen Ray Society, the American College of Radiology and the Radiological Society of North America, he has been personally known to many of us in the United States; and to a few who have had the privilege of more or less intimate acquaintance with this prince of our medical speciality, the demise of this grand man has brought a keen sense of personal loss.

Doctor Antoine Béclère was born in Paris on March 17, 1856, the son of Doctor Claude Béclère, who was also a practic-

ing physician. His early education at the Lyceum Condorcet was marked by special success in mathematics, Latin, and physics, while his clear and precise manner of thought enticed him in the direction of mathematics. His taste for philosophical discussion was intense. He was a great lover of reading; a library always constituted for him a promised land which he explored avidly. He was attracted towards the École Normal des Sciences, but his desire for independence induced him to choose medicine as a profession. Accordingly in the year 1873, together with his friends Walther and Siredey, he began his studies in the field of medicine, under the tutelage of Professor Tillaux. The close friendship of these three was destined to endure for sixty-five years.

Having become an "Externe of the Hospitals" in 1875, he spent a year at Lille where he continued his contact with Walther and Siredey, and became associated with Moissan, Chauffard and Pierre Marie.

In 1887, at the age of twenty-one, Antoine Béclère succeeded at the first examination in being named interne of the Hospitals, and began his service at once under Gérin-Roze, Duplay, Ollivier and Labric. While on Duplay's service he was in charge of the clinics of otology and of ophthalmology. Ever since his studies at Lille, where he acquired facility in the use of the ophthalmoscope, the study of the eye had possessed great interest for him, yet he hesitated about devoting himself exclusively to that specialty. He loved pediatrics, and was wont to recount with pleasure the hundred and forty tracheotomies he did while in the pediatric service. It was during this period that he gave special interest to the study of infectious diseases of childhood, a subject which in 1882 inspired his thesis on the contagion of rubeola. This thesis with its novel and original conclusions as to the source and manner of contagion, isolation and prophylaxis, represented at the time an epochal accomplishment. During the several subsequent years his research was extended to include the infectious diseases of the adult. He then concentrated on the subject of immunity by vaccination, an investigation which, together with preparation for his hospital staff examinations, engrossed his entire time. In 1893 the examinations for appointment to a hospital staff were successfully passed and Béclère began his first service as attending physician at the Hospital Saint Louis. Here he was one of the few to recognize the significance of the conceptions of Brown-Séquard. Here, too, he began the study and treatment of affections of the endocrine glands, going in person to the slaughter houses and selecting the fresh glands intended for his patients. He was among the first to achieve success in the treatment of myxedema and Addison's disease. Immunity against smallpox by vaccination and by serum therapy continued to occupy his mind; he worked constantly in this field and contributed greatly to the formulation of the laws of immunity which are now classic. His labors attracted attention outside of France; at the request of Queen Victoria, Lister wrote him requesting his documentations on this subject.

Thus by the end of 1895 Antoine Béclère was a pediatrician of renown; an investigator whose original researches were universally appreciated and recognized. Then came from Würzburg the announcement of Roentgen's discovery. Early in 1896, Béclère was invited to spend an evening with his friends Barthélemy and Oudin viewing some photographs and some screen images made with the new rays. During the séance he received an emergency call, and by the time he returned, the meeting was ended. His friends, however, seeing his great disappointment, called in one of the servants as a subject for fluoroscopy, and Béclère was amazed to view the beating of the heart, the throbbing of the aorta, the excursions of the diaphragm, and was astonished at finding a shadow in the apex of the lung. On inquiry it was learned that the patient had previously suffered a hemoptysis.

Béclère at once recognized the immense horizons opened up by this new procedure

of medical exploration. The very next morning he engaged Nugues, of the École Centrale, to supervise him in his studies on the new rays, and at once went about creating at his own expense a roentgen diagnostic set-up in his own medical service at the Hospital Tenon, and began immediately to act on the principle that to understand a subject well, one must teach it to others. Early in 1897 he commenced the teaching of medical roentgenology. This free instruction was the first, and for a long time the only, course of radiological instruction given in France, and during the following thirty years approval of his teaching was attested by the enrollment of thousands of physicians from every land on the globe.

To the new science Béclère addressed himself with passion; nothing discouraged him, neither the material difficulties, nor the sarcasm of his colleagues who suggested that it was highly belittling for a recognized physician, internationally known for his training, scientific accomplishments and promise to assume the calling of a "photographer," nor finally the indulgent contempt of those who spoke of the "childish distractions of Béclère." With unremitting enthusiasm he labored towards the publication of his "Radiodiagnostics" in 1896, and of his "Roentgen Therapy" in 1902. Within a few years his labors had touched all branches of medical roentgenology; he had established its basic essentials. For forty years he continued in his work, defining its indications, its technique and its results.

His interest in roentgenological progress carried him to other lands. In 1902 he visited Kienböck and Holzknecht in Vienna, and brought back with him the first dosage-measuring instrument, the quantitometer of Holzknecht. Although he had at first only a slight knowledge of the German language and none of English, he set himself to the task and translated word for word into French the books of Williams and of Holzknecht. This he kept up, acquiring facility in the reading of tongues he could not speak, accumulating notes, critical analyses, and other documents.

In this rapidly developing field of medical roentgenology, one finds everywhere the mark of Béclère's rare clinical sense, his unerring judgment. "The x-rays never deceive; it is we who deceive ourselves by erroneously interpreting their language," he wrote in those early days. Béclère never ceased to declare that radiology should be practiced by physicians and by them alone. Persuaded of the necessity of supplementing the findings of the roentgen screen and film with clinical observation, he set about a campaign to convince physicians and the public of this idea and with this object in view he published in 1905 his book on medical roentgenology for physicians.

Having been well trained in opththalmology, he insisted on the importance of adequately accommodating the retina to darkness before undertaking fluoroscopy and accomplished experiments to prove that the retina thus properly prepared became as much as two hundred times as sensitive as when first entering the dark room from daylight. It required years to convince his colleagues of the necessity of this simple rule and of many other essential basic precautions for effective roentgenologic examinations.

In 1907, Béclère reported to the French Congress of Surgery on the treatment of malignant tumors. His radiation therapy of cancer of the breast was already giving surprising results. The recent years have confirmed some of the beautiful results he early obtained in the employment of small repeated doses—results which later led him to the conviction that fractionated dosage was superior to massive dosage.

He began his studies on the treatment of uterine fibroids in the year 1908, an important year for him in that it marked his nomination to the Academy of Medicine, and in that year he founded the Société de Radiologie médicale de France. It was also in this year that he standardized his technique for the treatment of tumors of the hypophysis, a technique which is today recognized and utilized throughout the world. The first patient treated by Béclère,

thirty years ago, is today in excellent health, the mother of a family.

At this time he began to give great attention to the study of digestive disorders. Together with his friend Albert Mathieu, at the Hospital St. Antoine, he devoted more and more of his time to the roentgenological diagnosis of affections of the digestive tract, so that by 1912 he was prepared to make a momentous report on the major principles before the French Congress of Surgery, and in the following year before the International Congress of Medicine in London. This report was so complete in every detail that to this day little remains to be added.

Béclère's endeavor in therapy at this time was further marked by demonstration of the extraordinary sensitivity of the seminona which has assumed a place among the most original studies in roentgen therapy; the first case was subjected to roentgen treatment in 1905, and a comprehensive report of all his cases was made in 1916.

And now came the World War—1914 to 1918. Antoine Béclère because of his age was exempt from every sort of military obligation; however, having proffered his services, there was confided to him the direction of the Laboratoire de Physiothérapie at the military hospital, Vâl de Grace. He proceeded with the equipment of the mobile roentgenologic units, organized and supervised the 120 roentgen laboratories of the Gouvernement Militaire de Paris and developed numerous medical roentgenologists for the armies. Under this crushing load he bore up, accepting only two periods of leave in the four years, each of seven days only. The cross of an officer of the Legion of Honor for military services was awarded him as a partial recognition of his valuable services. He was particularly helpful to those in charge of the roentgen service of the American Expeditionary Forces.

In 1921, Béclère, having reached the age for retirement, gave up his post at the Hospital St. Antoine; his activities, nevertheless, did not cease, they were merely transferred elsewhere, deploying themselves in all their pristine energy and enthusiasm at the Fondation Curie where he continued his teaching of medical roentgenology. He became a fervent collaborator of that institution where reigns the ardent respect for science which had always been his own.

Béclère had received a roentgen injury, just as had nearly all of the pioneers in this work; however, he never spoke of it. He renounced diagnostic roentgenology and devoted himself entirely to roentgen therapy which absorbed his attention more and more. In lengthy articles he constituted himself a defender of roentgen therapy of uterine fibroids; he accumulated proved case reports, contributing in a very important way to this method of treatment. Numerous, indeed, were his other publications in the different fields of roentgen therapy.

Béclère had consecrated himself to radiology, sacrificing all else to this work since 1896; now, at seventy-five years of age, he enthusiastically resumed his researches on immunity, happy to be able at last to carry out projects dormant since his youth. At the Pasteur Institute, after tedious essays, he succeeded in transferring syphilis to the bovine family, and was having a heifer inoculated with the influenza bacillus with a view to producing an immunizing serum. The recent works of Peyton Rous and of Shope tend to verify the opinion which Béclère had always harbored as to the infectious origin of cancer; at the Curie Foundation, he was studying this aspect of the pathogenesis of cancer. These were the labors which were engrossing him at the end; in fact, the last time he went out was for the purpose of procuring experimental rabbits, a final gesture towards collecting the results of experimentation then in course of completion.

Béclère was made president of the Académie de Médecine in 1928, and 1931 saw him president of the Third International Congress of Radiology at Paris; uniting around a venerated and loved president, the "father of French radiology," were

1,340 participants from fifty different countries.

His eightieth year was feted—in spite of his protests—on May 10, 1936, this jubilee reuniting around him in a common affectionate respect, his colleagues, pupils and friends of France and from abroad. An issue of *Strahlentherapie* was dedicated to him, containing one hundred and thirty-seven original articles, contributed by the radiologists of twenty-nine countries. A jubilee edition written by his pupils anent his rich labors in the field of medicine was presented to him at the same time that he was awarded the gorgeous medal "a l'antique," struck with his image, and presented to him by Professor Regaud with the words: "In the most noble sense of this ancient word, you are the model of teachers." From all sides on this occasion he was the recipient of the most moving expressions of homage. These unforgettable evidences of respectful affection moved him intensely, surprised him even more. Antoine Béclère was modesty itself; were he proposed an honor, it would be refused, and only those accepted which were granted without his being consulted. His charity was abundant, his probity proof against every temptation; his lively intelligence, his faculty for enthusiasm, his taste for philosophy diverted him towards all sorts of subjects; his transports of feeling, however, cloaked by an intense reserve, a natural reticence, a reminder of his timidity as a youth, at times giving to his demeanor the semblance of coldness. However, his heart was warm, generous, untiringly devoted to the objects of his affections. Friendship was with him a true cult; inexhaustibly indulgent, he was a stranger to animosity. His thoughts were always obsessed with the desire to serve. "One does not live in order to take care of one's self, one lives to labor," was his constantly repeated remark. A tireless worker, Antoine Béclère added to his list twenty new publications after he was eighty years of age; throughout his long life he accorded himself—aside from his summer vacations—no respite; each Sunday found him at his work-table. He was an assiduous participant in medical congresses, seeking contact with the workers in his field, appreciating the confidential exchange of ideas which resulted therefrom. Mundane affairs never attracted him; nevertheless he was fond of music, of travelling, of museums of art, of the lofty mountains and softly glowing landscapes. He was admired by all; his prestige abroad was immense, was unsuspected by the great man himself, the man so simple and humble in his own estimation, who would have been astonished to read the words recently received from an eminent foreigner: "No radiologist has ever united around himself so much of respect and affection as has Doctor Antoine Béclère."

In addition to the honors previously mentioned, Dr. Béclère was made Honorary Physician to the Hospital St. Antoine; also Honorary President of the Society of Medical Radiology of France; was a member of the administrative council of the Fondation Curie; a member of the Conseil Superieur de l'Hygiene Social; docteur "Honoris Causa" of the University of Zurich and of Cologne; a member of the Academies of Medicine of Rio de Janeiro and of Turin; honorary member of the Royal Society of Medicine, of the various American radiological societies, and of numerous scientific and medical societies, both at home and abroad; elevated to the position of Commander of the Legion of Honor, and also made a Grand Officer of the Royal Order of the Polar Star.

Antoine Béclère died after a brief illness, attended by his children, Mlle. Antoinette Béclère who had devoted herself to him with such vigilant care during his declining years, and his son, Dr. Claude Béclère, who is continuing worthily the medical tradition inaugurated by his parents. Admired and mourned by his colleagues, his pupils, his innumerable friends, his appreciative patients, Antoine Béclère has gone to his last repose. Requiescat in pace!

JAMES T. CASE

ELWOOD E. DOWNS
1890—1939

DOCTOR Elwood E. Downs died suddenly in Woodbury, N. J., on March 18, 1939. The cause of death was an embolus which occurred during convalescence from an operation for acute appendicitis, March 8, 1939.

He was born in Franklinville, N. J., in 1890. After graduating from Hahnemann Medical College, Philadelphia, he engaged in private practice for several years. His radiological career begin with his training ing in the Department of Radiology of the Pennsylvania Hospital under the direction of Doctor David R. Bowen. Following this, he took charge of the Radiological Department of the Underwood Hospital, Wood-

bury, N. J. He was active in the development and management of the hospital and in 1929 became its secretary-treasurer. In 1928 he was appointed roentgenologist to the Jeanes Hospital, Philadelphia, and he later accepted the appointment of roentgenologist to the Salem Memorial Hospital, Salem, N. J.

In 1933 Downs was elected to membership in the American Roentgen Ray Society and his appointment to the Committee on Scientific Exhibits, of which he was twice chairman, soon followed. The success of the scientific exhibits in these years was largely due to his efficient and energetic direction. He also served one year as representative of the Section of Radiology on the Scientific Exhibit Committee of the American Medical Association. He was a Fellow of the American College of Radiology and a member of the Radiological Society of North America, a past president of the Philadelphia Roentgen Ray Society and also of the Radiological Society of New Jersey. His work on committees and as president of his local societies reflected the most energetic and thorough leadership.

Although not a constant contributor to radiological literature, he contributed valuable papers with his coworkers at the Jeanes Hospital on the care of the cancer patient, on lung changes subsequent to irradiation and on factors influencing the types of metastatic carcinoma of bone. The roentgen therapy of cancer was his major interest.

Downs' activities were confined not only to his profession. He was appointed to the Board of Education of Woodbury in 1933 and reappointed for a five year term in 1937. Five days after his first appointment he was elected president of the Board, an office he held continuously until his death. He was an active member of the Kiwanis Club.

His wife, Lydia Preston Downs, two sons and a daughter survive him.

Downs' life was cut short, in the midst of his numerous professional and civic interests. A congenial, sociable friend, possessed of humor, has been lost, one whose help and cooperation were always freely given and one for whom no effort was too great, or no task too difficult. To his community he stood as a representative of the highest type of physician and citizen. In his profession, his constant aim was to fulfill to the utmost his obligations to his patients and colleagues. This sudden and early ending of a life of accomplishment is a sad loss.

RALPH S. BROMER

HENRY SCHMITZ
1871—1939

FEW men, however gifted, have attained conspicuous proficiency in two independent medical specialties and have risen to commanding leadership in both, but that can be said in all truth of Doctor Henry Schmitz, who died April 17, 1939. So remarkably parallel were Doctor Schmitz's achievements in gynecology and therapeutic radiology that both these specialities may proudly claim him for their own.

Born at Kaiserswert, Germany, December 26, 1871, Henry Schmitz in his youth attended the Realschule at Krefeld and later the University of Karlsruhe. In his early twenties he came to Chicago, entered the School of Medicine

of Loyola University and received the degree of M.D. in 1897. In 1912 the University of Valparaiso conferred on him the degree of A.M., and in 1922 he received the degree of LL.D. from Loyola University.

With his natural talents, untiring industry and strong personality, Doctor Schmitz was bound to rise to eminence in his dual fields of endeavor. At various periods he was attending gynecologist at St. Mary of Nazareth, Frances Willard and Augustana Hospitals. Since 1917 he had been professor and head of the Department of Gynecology at Loyola University. At the time of his death he was attending gynecologist at Cook County and Mercy Hospitals and consulting gynecologist at Misericordia and Holy Cross Hospitals. His "Manual of Diseases of Women," published in 1912, and "Handbook of Gynecology," published in 1915, found ready acceptance as standard texts. In this field he was an outstanding member of many societies, including the Chicago Gynecological Society, of which he was president in 1930, the Central Association of Obstetricians and Gynecologists, the American Association of Obstetricians, Gynecologists and Abdominal Surgeons, and the American College of Surgeons. Since 1931 he had been secretary of the Board of Trustees of the Lewis Memorial Maternity Hospital.

Although he began as a gynecologist and so continued to the end, he was inevitably attracted into the field of radiotherapy where he quickly became a leader, and his book, "The Physics and Principles of Radition Therapy," is recognized as a reliable and authoritative exposition of the subject. In 1933 he founded and was made director of the Institute of Radiation Therapy at Mercy Hospital. Here he installed the the first supervoltage roentgen-ray apparatus operated in the United States, and the installation has been in constant service since. Many radiologic organizations paid him honor and profited from his membership. He was a member of the Chicago Roentgen Society, the American Radium Society, of which he was president in 1922, the Radiological Society of North America which awarded him its Gold Medal in 1930, and the American College of Radiology. In 1938 he gave the Janeway Lecture before the American Radium Society, and this organization also bestowed on him its Medal. When The American Board of Radiology was established in 1934 he was chosen as one of its original members and shortly before his death had been reelected.

Married in the year that he was graduated in medicine to Meta Elizabeth Lenzen, who still survives, Doctor Schmitz was devoted to his family above all else, and with pride saw his three sons, Henry, Herbert and Robert, follow in his footsteps and become physicians. During the World War, Doctor Schmitz held the rank of captain and was surgeon of Base Hospital Unit No. 11 until 1918.

Further appraisal of Doctor Schmitz as physician, gynecologist and radiologist is unnecessary. His splendid career speaks eloquently for itself. All his professional honors were well earned by persevering effort and despite the handicap of adoption into a foreign land with an unfamiliar tongue. As a man he was equally admirable. Brought up under strict German discipline, he maintained a dignified reserve that seemed to forbid easy familiarity. But under this seeming austerity was an amiable, sensitive, almost sentimental temperament, and a sincere concern for the welfare of those about him. By no means a recluse, he enjoyed travel, had marked talent in music, collected books, took pleasure in horseback riding, hunting and fishing, and was always a delightful companion to his friends. Frank but friendly in criticism, alert and plastic of mind to the last, wise in judgment, scrupulously fair, loyal in friendship, Henry Schmitz will long be missed by his associates, and the medical profession will long profit from the legacy of his work.

B. R. KIRKLIN

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

United States of America

American Roentgen Ray Society
Secretary, Dr. C. B. Peirce, Royal Victoria Hospital, Montreal, Canada. Annual Meeting: Chicago, Ill., Sept. 19–22, 1939.

American College of Radiology
Secretary, Mac F. Cahal, 540 N. Michigan Ave., Chicago, Ill. Next Annual Meeting: New York City, June 12, 1940.

Section on Radiology, American Medical Association
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: New City City, 1940.

Radiological Society of North America
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Atlanta-Biltmore Hotel, Atlanta, Ga., Dec. 11–15, 1939.

Radiological Section, Baltimore City Medical Society
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

Radiological Section, Connecticut Medical Society
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets twice annually in May and September.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. W. W. Furey, 6844 Oglesby Ave., Chicago.

Radiological Section, Los Angeles Co. Med. Soc.
Secretary, Dr. Wilbur Bailey, 2007 Wilshire Blvd., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

Radiological Section, Southern Medical Association
Secretary Dr. Roy G. Giles, Temple, Texas.

Brooklyn Roentgen Ray Society
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

Buffalo Radiological Society
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

Chicago Roentgen Society
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

Cincinnati Radiological Society
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

Cleveland Radiological Society
Secretary, Dr. H. A. Mahrer, 10515 Carnegie Ave. Meets at 6:30 P.M. at Mid-Day Club rooms on fourth Monday each month, October to April, inclusive.

Denver Radiological Club
Secretary, Dr. E. A. Schmidt, 4200 E. 9th Ave., Denver, Colo. Meets third Tuesday of each month.

Detroit Roentgen Ray and Radium Society
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

Florida State Radiological Society
Secretary, Dr. J. N. Moore, 210 Professional Bldg., Ocala, Florida. Meetings in May and November.

Georgia Radiological Society
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets in November and at annual meeting of Medical Association of Georgia in the spring.

Illinois Radiological Society
Secretary, Dr. E. P. Halley, Decatur and Macon County Hospital, Decatur, Ill. Meetings held quarterly, time and place designated by president.

Indiana Roentgen Society
Secretary, Dr. C. C. Taylor, 23 E. Ohio St., Indianapolis, Ind. Meeting held the second Sunday in May annually.

Kentucky Radiological Society
Secretary, Dr. J. C. Bell, 402 Heyburn Bldg., Louisville. Meets annually in Louisville on third Sunday afternoon in April.

Long Island Radiological Society
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:30 P.M.

Michigan Association of Roentgenologists
Secretary, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing. Three meetings a year, Fall, Winter, Spring.

Milwaukee Roentgen Ray Society
Secretary, Dr. I. I. Cowan, Mt. Sinai Hospital, Milwaukee, Wis. Meets monthly on first Friday at University Club.

Minnesota Radiological Society
Secretary, Dr. J. P. Medelman, 572 Lowry Medical Arts Bldg., St. Paul.

Nebraska Radiological Society
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets first Wednesday of each month, at 6 P.M., at either Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. A. O. Hampton, Massachusetts General Hospital, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

Radiological Society of New Jersey
Secretary, Dr. W. J. Marquis, 198 Clinton Ave, Newark. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by president.

New York Roentgen Society
Secretary, Dr. R. D. Duckworth, 170 Maple Ave., White Plains, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

North Carolina Roentgen Ray Society
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

Central New York Roentgen Ray Society
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year—January, May, November.

Pacific Roentgen Club
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport, Pa. Annual meeting, June 2 and 3, 1939. Bedford Springs Hotel, Bedford, Pa.

Philadelphia Roentgen Ray Society
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St

Pittsburgh Roentgen Society
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave., Meetings held second Wednesday each month, 4:30 P.M., October to June at various hospitals.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St., Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

St. Louis Society of Radiologists
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

San Francisco Radiological Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

South Carolina X-Ray Society
Secretary, Dr. Hillyer Rudisill, Jr., Roper Hospital, Charleston. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg. Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. H. C. Harrell, 517 Pine St., Texarkana, Texas. Next regular meeting in Temple, Texas, 1939.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. V. W. Archer, University Hospital, University, Va. Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets monthly on third Thursday, from November to June inclusive, at 8:15 P.M., 32 Welbeck St., London.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Faculty of Radiologists
Secretary, Dr. Barbara M. Key, 32 Welbeck St., London, W.1, England.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to Nov. incl. for scientific discussion.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto, 5, Ontario.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext., Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel. Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during month of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgensellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the fall.

Societa Italiana Radiologia Medica
Secretary, M. Ponzio, University of Turin, Prof. Turin

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson. Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin. Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky. Meets monthly on first Monday at 8 o'clock.

Polish Society of Radiology
Secretary, Dr. Jan Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime:

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6:30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University.
Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

AMERICAN ROENTGEN RAY SOCIETY

SECTION ON INSTRUCTION

Abstracts of Courses Offered

Fortieth Annual Meeting,
Palmer House, Chicago, Ill.,
September 19–22, 1939

SECTION ON INSTRUCTION

B. R. Kirklin, *Director*

President-elect Jenkinson, with the approval of the Executive Council, has created a Section on Instruction for this year's annual meeting. He has arranged his program so that the instruction courses will be given between the hours of 2.00 and 4.30 each afternoon. Each period will last 1¼ hours. Nothing else will be scheduled during this time which allows everyone at the meeting to attend two instruction periods each afternoon.

This Section presents for 1939:

1. One four-period Sequential Course.
2. Twenty-nine single period courses on Diagnostic Roentgenology.
3. Nineteen single period courses on Therapeutic Radiology.
4. Three single period courses on miscellaneous subjects.

GENERAL INFORMATION

Conference Periods

Tuesday, Wednesday, Thursday and Friday afternoons

First period.....2:00 to 3:15
Second period.....3:15 to 4:30

Location

All courses will be given on the seventh floor of the Palmer House, but full information may be secured at the general registration desk.

How to Secure Conference Tickets

Following page 1043 will be found a pink general order sheet. First, second and third choices for each period should be carefully selected. The number attending each period will be limited to from twenty to forty persons. If directions as given on the order sheet are followed explicitly, errors in completing reservations will be minimized.

It is possible for one to attend only eight periods of instruction so this schedule should be noted carefully in arranging individual orders for tickets.

Reservations will be made in the order of receipt of the pink forms. Those who are not members of the American Roentgen Ray Society will be charged a nominal fee of $1.00 per period or a maximum fee of $5.00 for five or more periods.

If the courses are not filled by the time of the meeting, tickets will be available at the registration desk on Monday, September 18, and thereafter during the meeting.

Holders of Tickets

Those who do not have a proper ticket for the assigned conference will not be permitted to enter the room. Pages will be assigned to each conference room to collect tickets.

Duplications

Due to the anticipated heavy registration a few courses will be duplicated by two instructors.

Code

Tuesday

1st period—2:00 to 3:15 = T-1
2nd period—3:15 to 4:30 = T-2

Wednesday

1st period—2:00 to 3:15 = W-1
2nd period—3:15 to 4:30 = W-2

Thursday

1st period—2:00 to 3:15 = Th-1
2nd period—3:15 to 4:30 = Th-2

Friday

1st period—2:00 to 3:15 = F-1
2nd period—3:15 to 4:30 = F-2

SPECIAL SEQUENTIAL COURSE

This course will run for four periods and will be a continuous course.

[A] Radiologic-Pathologic Conference on Bone Tumors

Periods: T-1, W-1, Th-1, F-1

JOHN T. MURPHY, Toledo, Ohio
PLINN MORSE, Detroit, Michigan

Cases of bone pathology will be shown. Both the roentgen and the microscopic findings will be discussed and the clinical course of the disease will be stressed. Complete follow-up of the patient will be shown. Differential roentgenologic diagnosis will be stressed. This course will be conducted as a teaching seminar and all those in attendance may participate in the discussion. No part of this course will be repeated.

SINGLE LECTURE PERIODS

MISCELLANEOUS

Course 101 **Periods: Th-2, F-2**

J. GERSHON-COHEN, Philadelphia, Pa.

The Physiology of the Stomach

A review of the motor and secretory phases of gastric and duodenal physiology. Some newer experimental developments and their bearing on the roentgen examination of the gastrointestinal tract.

Course 102 **Periods: Th-1, F-1**

FRED J. HODGES, Ann Arbor, Mich.
ISADORE LAMPE, Ann Arbor, Mich.

Filing and Cross-indexing Roentgen-Ray Records:
Demonstration of a Simple and Efficient Method

In accordance with the recently expressed demand of the American Medical Association and the American Board of Radiology that departments of radiology desiring approval of these organizations as training posts for young men equip themselves with some reliable method of cross-indexing roentgen findings, this instruction course has been devised as a forum at which this matter can receive the consideration and discussion which it deserves. The purposes of diagnostic cross-indexing and the ultimate accomplishment expected will be presented and discussed. The fundamental necessity for simple and accurate film and record filing, together with a description of various methods of proved worth which are now in practice will be presented.

A simple and efficient method of cross-indexing will be described and demonstrated, and materials necessary for putting this method into actual operation will be provided to members attending this course.

Course 103 **Periods: T-2, W-2, Th-2, F-2**

W. WALTER WASSON, Denver, Colo.

The Anatomy, Physiology, and Mechanics of the Chest as a Basis for the Study of Chest Diseases and Their Classification

This is an effort to portray the chest so that the clinician or radiologist can actually visualize the thoracic viscera and their diseases. A child begins life with certain anatomical structures which change with the years both as a result of physiological processes and disease. The pathological reactions which the clinician or the radiologist are called upon to diagnose are definitely influenced by the particular physiology and mechanics of this anatomy. Accordingly, any classification of chest disease must be based upon the pathological reactions of disease as influenced by anatomy and of the physiology and mechanics of this anatomy.

The presentation will be made in the following sections:

1. Anatomy of the Lungs. Period: T-2
2. Physiology and Mechanics of the Chest and Particularly of the Lungs. Period: W-2
3. The Classification of Diseases of the Lungs. Period: Th-2
4. Illustrations of the Different Diseases of the Lungs and their Diagnosis. Period: F-2

SINGLE PERIOD COURSES

DIAGNOSTIC ROENTGENOLOGY

Course 201 **Periods: T-1, W-1**

VINCENT W. ARCHER, University, Va.
F. B. BOGART, Chattanooga, Tenn.

Chest Findings in "Country Diseases"

Pulmonary findings in (1) tularemia; (2) pneumonia; (3) pleural effusion; (4) bronchitis; (5) nodular infiltration; (6) actinomycosis; (7) blastomycosis; (8) Malta fever.

Course 202 **Periods: Th-2, F-2**

V. W. ARCHER, University, Va.

Roentgenologic Manifestations in Osteomyelitis

Negative findings early in the disease. Examples of atypical disease. Roentgenographic demonstration of structural weakness necessitating immobilization to prevent deformity. Demonstration of sequestra and pockets as cause of draining sinuses. Brodie's abscess. Late recurrences. Differential diagnosis between osteomyelitis, lues, mycotic infection, tuberculosis, and tumor.

Course 203 **Periods: Th-1, F-1**

LOUIE T. AUSTIN, D.D.S.
Rochester, Minn.

Interpretation of the Dental Roentgenogram

Subject will be presented by means of a table clinic, using transparencies and selected dental roentgenograms showing various dental conditions. Significance or insignificance of the condition will be pointed out.

Course 204 **Periods: Th-1, F-1**

PAUL A. BISHOP, Philadelphia, Pa.

Examination and Diagnosis of Lesions of the Temporomandibular Joint

The frequency with which injuries of the temporomandibular joint are overlooked, both clinically and roentgenographically, has led to an appalling number of permanent, serious disabilities of the mandible. A technique for the roentgenographic study of this joint is presented with lantern slide demonstration of acute and chronic injuries, as well as various non-traumatic conditions.

Course 205 **Period: T-2, W-2**

RALPH S. BROMER, Philadelphia, Pa.

The Differential Diagnosis of Skeletal Changes Occurring in Diseases of Infants and Children

The time allotted will be spent in discussing the differential roentgen diagnosis of skeletal changes occurring in diseases of infancy and childhood. All such diseases cannot be included in the time available for the course. Case material will be chosen from the following list: congenital syphilis, rickets, infantile scurvy, tuberculosis, lead poisoning, the blood dyscrasias, xanthomatosis and allied conditions, osteogenesis imperfecta, achondroplasia, multiple enchondromata, multiple cartilaginous exostoses, metastases caused by neuroblastoma, osteochondritis and endocrine disturbances. Wherever possible the early roentgen changes will be emphasized. The question of differential diagnosis will be approached from the standpoint of the predisposition of the various diseases to affect certain bones or certain areas of individual bones. Thus in the case of the long bones, differential roentgen signs of the disease processes in the epiphysis, the diaphysis, the metaphysis, the periosteum, cortex, etc., will be given in detail.

Course 206 **Periods: Th-1, F-1**

JOHN D. CAMP, Rochester, Minn.

Opaque Oil Myelography

This course will emphasize the indications for the use of lipiodol in the examination of the spinal subarachnoid space and the technique of the various procedures necessary for the location of lesions in various areas. The significant filling defects observed with intramedullary, intradural and extradural lesions will be demonstrated and the differential diagnosis discussed. Lantern slides and moving pictures will be used.

Course 207 **Periods: T-1, W-1**

JOHN R. CARTY, New York City

Soft Tissue Roentgenography

The pathological and anatomical basis of soft tissue roentgenography is briefly discussed, with particular reference to the newer concepts regarding fascial planes.

The essential points of the technical procedures are discussed and emphasis is placed on the necessity for an adequate understanding of the technical factors if success in this field is to be expected. Only practical aspects are to be considered, and a simple technical procedure is outlined which may be fol-

lowed with the equipment found in the average roentgenographic office or department.

Following the discussion of technique the pathological conditions in the soft tissues which may be demonstrated roentgenographically are discussed and divided into appropriate groups, as follows:

Vascular Conditions: Soft tissue roentgenography is valuable in the study of arteriosclerosis and varicose veins. Information may be obtained as to whether or not the deep veins are involved. Occasional valuable information may be obtained regarding arteriovenous aneurysms.

Soft Tissue Tumors: Information regarding the extent and character and whether or not the tumor is malignant may often be secured following roentgenographic examination. It is my opinion that no examination for bone tumor is complete without a soft tissue study also. Differential diagnosis between fibroid periosteal sarcoma and osteogenic sarcoma may sometimes be made. The presence of minute deposits of calcium caused by osteogenic elements in the soft tissues is the deciding factor. These calcium dots are usually entirely obliterated in roentgenograms made for bone detail. In hemangiomata distribution and location of the vessels supplying the tumor can often be ascertained. This may be of considerable value to the surgeon.

Muscle Conditions: Calcified hematomata are well shown in a soft tissue study. Occasionally a ruptured muscle may be demonstrated. Early atrophy at times may be demonstrated before there is actual reduction in size of the limb.

Infectious Conditions: Soft tissue roentgenography is invaluable in the diagnosis of gas gangrene, particularly for determining the extent of the disease. Soft tissue roentgenography is useful in the study of elephantiasis and may help in the differentiation of various types of edema. Soft tissue study of inflamed bursae is helpful, particularly where there is an absence of calcium-like material.

Soft tissue roentgenography of the larynx is briefly discussed, with special reference to carcinoma, edema and retropharyngeal abscesses.

In conclusion, the technique and scope of fasciagraphy is briefly discussed, and films shown which demonstrate its usefulness in certain selected conditions.

Course 208 **Periods: T-2, W-2**

W. EDWARD CHAMBERLAIN, Philadelphia, Pa.

Technique and Interpretation of Oxygen Myelography

Oxygen has now been used successfully in hundreds of cases as the contrast medium for myelography. It has many advantages over other media but the roentgenographic requirements are very exacting.

Lumbar puncture vs. cisternal puncture for introduction of the oxygen; methods of increasing scope of lumbar puncture route; adaptation of ordinary conventional roentgenographic apparatus to this work; essential factors in technique; stereoscopy essential in lateral as well as dorsal projections; stereoscopic shift across long axis of spine; value of comparing lateral projections with spine in hyperflexion and hyperextension; value of "over-exposing" films; oblique projections of little value except in cervical and upper thoracic regions; suggestions for after-care of patients.

Course 209 **Periods: Th-2, F-2**

HOWARD P. DOUB, Detroit, Mich.

The Invertebral Disc

This discussion will be limited as much as possible to the disc itself, but owing to its intimate relationship to the vertebrae, it will be necessary to consider the spine to some extent.

We wish to present the anatomy of the disc and its vascular supply together with reference to defects in its development which often lead to abnormalities in later life. Changes in the fibrous structure and in the cartilage plates, due either to disease or trauma, will be brought out. The effect of these changes on the vertebral column as a whole will then be considered.

The relationship of the disc to spinal deformities, such as the arthritides, kyphoses, tumors and injuries will also be discussed.

Course 210 **Periods: T-1, W-1**

C. G. DYKE, New York City

The Normal Encephalogram and Ventriculogram

This seminar will deal with the history of pneumoencephalography, the indications and contraindications for the procedure, the reactions to the test, the preparation of the patient, and the roentgen technique. The discussion of the above subjects will be followed by a thorough roentgen study of the lateral ventricles, the basal cisterns and the cortical markings, and also the structures which bound them. The demonstration will be illustrated.

Course 211 **Periods: Th-2, F-2**

C. G. DYKE, New York City

Pneumo-encephalographic Diagnosis of Brain Tumor

This period will be devoted to an enumeration of the criteria used in the diagnosis of the various types of intracranial tumors. The characteristic changes

produced by some of the neoplasms will be emphasized. The demonstration will be fully illustrated.

Course 212 **Periods: Th-2, F-2**

JOHN T. FARRELL, JR., Philadelphia, Pa.

Roentgen Diagnosis of Lesions of the Esophagus

The technique of roentgen examination of the esophagus with liquids, semi-solids, and solids, together with the indications and limitations of each, will first be presented. This will be followed by consideration of the roentgen anatomy and physiology. Study of pathological states will embrace the diagnosis and differential diagnosis of congenital, inflammatory, traumatic, functional, and neoplastic conditions of the organ.

Course 213 **Periods: T-2, W-2**

ROSS GOLDEN, New York City
PAUL C. SWENSON, New York City

Diseases of the Small Intestine

A. Method of examination
B. Normal small intestine
C. Disturbances in physiology
   1. Multiple peritoneal adhesions
   2. Mesenteric lymphadenitis
   3. Vagotonia
   4. Deficiency states
      a. Non-tropical sprue, adult celiac disease (chronic steatorrhea), infantile celiac disease
      b. Dietary deficiency
      c. Low serum albumin
      d. Acholia
   5. Allergy
   6. Ileus (paralytic and mechanical)
D. Inflammations
   1. Tuberculosis
   2. Nonspecific enteritis
E. Neoplasms
   1. Benign
   2. Malignant
      a. Carcinoma, carcinoid
      b. Lymphoblastoma (localized)
         (diffuse)

Course 214 **Periods: T-2, W-2**

A. O. HAMPTON, Boston, Mass.

Technique and Interpretation of Lateral Chest Roentgenography

The discussion will include:
1. Technique of taking roentgenograms in the lateral view.
2. Illustration of normal variations.
3. The importance of the lateral examination of the intrathoracic portion of the trachea, the substernal area and the posterior mediastinum.
4. The shape and location of the various types of consolidation including tumors and infarcts.
5. The appearance of shadows produced by bronchial obstruction and bronchiectasis.
6. A consideration of the interlobar fissures, particularly the importance of change in position associated with alterations in size of the various lobes, secondary to bronchial occlusion and inflammatory disease. The demonstration of emphysematous blebs and cyst-like cavities.

Course 215 **Periods: Th-1, F-1**

C. HOWARD HATCHER, Chicago, Ill.
PAUL C. HODGES, Chicago, Ill.

Surgical, Roentgenological and Pathological Findings in Certain Bone Lesions

Roentgenograms, sections of tissue, specimens and photomicrographs will be demonstrated to illustrate the gross and microscopic pathology underlying the roentgen findings in such bone diseases as neoplasm, tuberculosis, osteomyelitis, and aseptic infarction.

Course 216 **Periods: T-1, W-1**

PAUL C. HODGES, Chicago, Ill.
EDWARD M. DAVIS, Chicago, Ill.

Roentgen Pelvimetry and Fetometry

The indications for roentgen pelvimetry and fetometry, the technique of making the measurements, and the application of the measurements to clinical obstetrics will be considered. Models, specimens, charts and roentgenograms will be demonstrated. Opportunity will be given for questions and discussion.

Course 217 **Periods: Th-2, F-2**

KARL KORNBLUM, Philadelphia, Pa.

Tumors about the Sella Turcica

The roentgen examination of the head with special reference to the sella turcica, emphasizing particularly the need of careful roentgenographic technique. The anatomy of the region of the sella turcica will be given and attention directed to the cardinal changes produced by tumors in its vicinity. The characteristic deformities occurring in the intrasellar, suprasellar and parasellar tumors and neoplasms arising in the sphenoid sinus will be considered.

Course 218 **Periods: T-2, W-2**

IRA H. LOCKWOOD, Kansas City, Mo.

Secondary Tumors of the Lung and Their Roentgenologic Manifestations

This course will cover the roentgenologic manifestations together with surgical and autopsy findings, and gross and microscopic pathology of the following conditions:

Intrathoracic myxolipoma, thymoma, Hodgkin's disease, apical chest tumors, and secondary tumors of the lung from the following primary lesions: the adrenal tumors, kidney, cervical region, myxosarcoma, osteogenic sarcoma, chondromyxosarcoma, melanoma; tumors of the testicle, including carcinoma and teratoma, and carcinoma of the breast.

Course 219 **Periods: Th-2, F-2**

SHERWOOD MOORE, St. Louis, Mo.

Technique and Clinical Application of Body Section Roentgenography

The lecture will consist of a brief discussion of body section roentgenography and the methods employed for this purpose. There will be an appraisal, both anatomical and pathological, of the clinical use and value of this method of examination.

Course 220 **Periods: Th-1, F-1**

B. H. NICHOLS, Cleveland, Ohio

Excretory Urography

The technique of excretory urography will be demonstrated, including the injection of the opaque media, and the most advantageous time for making the films will be pointed out. Compression and other variations will be discussed as indicated. The type of case where excretory urography is definitely indicated will be described and its value as a functional test will be pointed out with films demonstrating these various points. The interpretation of films made by this method and the possibility of errors in interpretation will be considered.

Course 221 **Periods: T-2, W-2**

B. H. NICHOLS, Cleveland, Ohio

Retrograde Pyelography

Retrograde pyelography is a valuable adjunct to the interpretation of pyelograms. This lecture will illustrate the variations in technique necessary to demonstrate various kidney and ureteral diseases which may be suspected and the preferable procedure in lesions involving the ureter will be considered. Lantern slides will illustrate the characteristic changes found in pyelograms of lesions of the kidney and ureter.

Course 222 **Periods: T-2, W-2**

CARLETON B. PEIRCE, Montreal, Que.

Differential Diagnosis of Non-tuberculous Lesions of the Lung

Due to the brief time available, the major emphasis will be placed upon the fundamental pathologic physiology in each of the following major groups, and correlated with the roentgenologic evidence available for differential diagnosis:

1. Congenital variation
   a. Supernumerary lobulation
   b. Developmental absence of a lobe or lobes
   c. Congenital pulmonary cysts
2. Mechanical disturbance
   a. Emphysema
   b. Atelectasis
   c. Pneumothorax
   d. Mediastinal lesions
   e. Abnormal thoracic cage
   f. Cardiovascular disease
3. Inflammation
   a. The pneumonias
   b. Their sequelae
   c. Silicosis
   d. Mycosis
   e. Bronchitis
4. Neoplasm
   a. Primary carcinoma
   b. Pulmonary lymphoblastoma
   c. Sarcoid
   d. Benign tumors
   e. Metastatic neoplasms

Course 223 **Periods: T-1, W-1**

HOLLIS E. POTTER, Chicago, Ill.

Roentgen Diagnosis of Silicosis

Film and lantern slide demonstration of the essential changes in various stages of silicosis. Differentiation from linear, nodular, and massive lesions caused by other stimuli. Emphasis on the legal aspects of the disease.

Course 224 **Periods: Th-1, F-1**

LEO G. RIGLER, Minneapolis, Minn.

Roentgen Diagnosis of Pleural Effusions

The anatomy, physiology and physical characteristics of the pleura and pleural space will be reviewed. The importance of these factors in the roentgen consideration of pleural collections will be emphasized. Early diagnosis and differential diagnosis of fluids in the pleural cavity, free and encapsulated, will be reviewed. The differential findings exhibited by exudates and transudates and encapsulated collections will be demonstrated. Roentgenologic findings in pneumothorax and its complicated aspects such as adhesions, encapsulations, fluid and mediastinal hernia will be detailed. The technique of the roentgenoscopic and roentgenographic examination of the pleural cavity for disease will be considered.

Course 225 **Periods: T-1, W-1**

L. R. SANTE, St. Louis, Mo.

Bronchial Occlusion

Tracheal obstruction

Roentgen manifestations and causes

Complete bronchial obstruction resulting in atelectasis: massive type from obstruction of main stem bronchus; lobar form from occlusion of larger bronchial branches; lobular form resulting from occlusion of smaller bronchial subdivisions.

The causes and conditions which give rise to these various types of bronchial occlusion; their association with other conditions and diseases such as aspiration of foreign body, trauma, pulmonary tuberculosis, bronchogenic tumor, postoperative inhibition, general debility, weakness, etc.

Incomplete bronchial occlusion resulting in obstructive emphysema: massive involvement of entire lung (Manges' sign), smaller bronchial subdivisions, bronchiectasis and pseudobronchiectasis from partial bronchial obstruction by foreign body of long sojourn and from bronchogenic tumor.

Course 226 **Periods: Th-2, F-2**

RICHARD SCHATZKI, Boston, Mass.

Roentgen Diagnosis of Gastritis

Over-emphasis and marked criticism characterize the present attitude towards roentgen diagnosis of gastritis. This course tries to evaluate critically our knowledge at this time. Its emphasis is laid upon the practically important features connected with the diagnosis and differential diagnosis of gastritis, and not on theoretical considerations. The reasons why, in spite of the progress of gastroscopy, gastritis is still a problem for everyday roentgenology will be illustrated.

The round table discussion will include the following questions:

General principle and technique of the gastric relief demonstration; roentgen findings in some types of gastritis; critical discussion of the possibilities and limitations in regard to roentgenological diagnosis of gastritis; differential diagnosis.

Course 227 **Periods: T-1, W-1**

WENDELL G. SCOTT, St. Louis, Mo.

Technique and Clinical Application of Roentgen Kymography in Diseases of the Heart

The demonstration will consist of a presentation of the basic principles of roentgen kymography and an explanation of the roentgenographic technique. A series of lantern slides will be used to demonstrate characteristic kymograms as seen in:

1. Valvular diseases of the heart.
2. Diseases of the pericardium.
3. Diseases of the myocardium.

The value of roentgen kymography in forming the clinical diagnosis and prognosis in heart disease will be discussed. An effort will be made to present the subject from the practical and clinical viewpoint.

Brief mention will be made of the use of roentgen kymography in diseases of the thorax and of the gastrointestinal tract.

Course 228 **Periods: Th-1, F-1**

M. C. SOSMAN, Boston, Mass.

Pituitary Adenomas: Diagnosis, and Treatment by Irradiation

The author will discuss the differential diagnosis between extrasellar tumors which give roentgen appearances simulating pituitary tumors and the true intrasellar tumors. The clinical, roentgenological and therapeutic differences between the chromophobe, chromophil and basophil types will be discussed. The value and the results of radiation treatment will be presented and illustrated by lantern slides.

Course 229 **Periods: T-2, W-2**

HARRY M. WEBER, Rochester, Minn.

The Selection and Application of Roentgenologic Methods of Examining the Large Intestine

General Considerations. The function of the roentgenologic examination. Its position as an important

part of a cooperative diagnostic effort in which the clinical, proctosigmoidoscopic and clinical laboratory examinations all have significant contributions to make to the final diagnosis. The foundations in normal and pathologic anatomy for significant roentgenologic findings.

The Roentgenologic Examination of the Colon.

(1) The examination of the abdominal field without the use of contrast substances. Roentgenoscopy. Roentgenography. Indications. Limitations.

(2) The Contrast Meal. The traditional procedure. Composition of the contrast meal. Method in administration and observation: roentgenoscopy; roentgenography. Preparation of patient. Improper applications. Indications and contraindications for its use. "Physiologic" vs. "unphysiologic" aspects.

(3) The Contrast Enema. Preparation of the examiner. Preparation of the patient. Composition of the contrast enema. The fundamental importance of roentgenoscopy. The conduct of the roentgenoscopic examination. "Spot" roentgenography. Elaborations: (*a*) the examination after the bulk of the enema is evacuated; advantages; the lowermost ileum; (*b*) the double contrast enema; special consideration and precautions when this examination is contemplated; indications; special advantages; the luxury of alert and competent clinical and especially proctoscopic consultants; roentgenographic technique; the advantages of a simple instrumentarium; why stereoroentgenography?

SINGLE PERIOD COURSES

THERAPEUTIC RADIOLOGY

Course 301 **Periods: Th-1, F-1**

HARRY H. BOWING, Rochester, Minn.

Radiation Treatment of Carcinoma of the Cervix Uteri

The direction of the therapeutic effort in a case of carcinoma of the uterine cervix is today a major radiotherapeutic problem. This malignant neoplasm is the most common type of new growth seen in a gynecologic clinic. It holds a place of priority in the field of therapeutic radiology. It is good for medicine, and for therapeutic radiology in particular, for us to get together and, through demonstrations, discussions and expression of opinions, make substantial progress in advancing our knowledge. Topics for discussion:

Group I. (1) special anatomic considerations, etiology and predisposing factors; (2) how to diagnose carcinoma of the uterine cervix; (3) a suitable classification of all cases; (4) the gross pathology and microscopic histology; (5) biopsy procedures; (6) recognition of associated inflammatory lesions; (7) differential diagnosis.

Group II. (1) factors influencing radiosensitivity; (2) satisfactory methods of classifying the radium treatments; (3) the gross characteristics of the lesions and the selection of suitable radiation treatment factors; (4) the histologic grade of malignant change and its evaluation; (5) an efficient method of radium therapy, principles and technique; (6) roentgen therapy in the treatment of primary and secondary lesions; (7) complications arising during the course of treatment and their management; (8) the treatment of carcinoma of the cervix following supracervical hysterectomy.

Group III. (1) immediate and five-year "cures"; (2) the morbidity associated with early and with advanced cases; (3) the treatment of recurrences; (4) hospital mortality in the initial and late treatment phases.

Course 302 **Periods: T-1, W-1**

ARTHUR U. DESJARDINS, Rochester, Minn.

Lymphoblastoma (Hodgkin's Disease, Lymphosarcoma and Leukemia)

Prominent clinical features of Hodgkin's disease and lymphosarcoma; presenting symptoms and their relative importance; involvement of mediastinal nodes; involvement of retroperitoneal nodes; involvement of other nodes; extranodular infiltration; involvement of skin; great variation in complications; pathology; condition of the blood; treatment in relation to anatomic distribution of the disease and of its complications; quantity and quality of rays; variations in radiosensitiveness and reasons therefor; effect on the blood cells; repetition of treatment and factors which should govern it; prognosis; factors governing survival.

Course 303 **Periods: T-1, W-1**

E. C. ERNST, St. Louis, Mo.

Practical Concepts of Radiation Treatment of Carcinoma of the Cervix Uteri

The practical irradiation management of carcinoma of the cervix will be discussed both from the standpoint of the institutional tumor clinic and the private office procedure. Although realizing that the radiation treatment standards continue to remain somewhat in a state of flux and that individualization in the application of roentgen rays and radium is a most essential consideration, nevertheless certain fundamental concepts in our routine procedures are

most helpful in the management of cancer of the cervix. These and many other practical therapeutic considerations, including external roentgen therapy, intracavity radium and roentgen methods of treatment and the dosage measurement problems, will be discussed and illustrated.

Course 304 **Periods: Th-1, F-1**

G. FAILLA, New York City

Some Aspects of Radiosensitivity

Variation of radiosensitivity with cell type, stage of development, etc.

Influence of circulation on cell reaction to radiation in accordance with author's theory of the biological action of ionizing radiations. Experimental findings tending to support theory.

Relative radiosensitivity of normal and pathological tissues most important factor in radiation therapy. Ways in which radiosensitivity ratio may be improved. Possible influence of wave length on this ratio.

Applications to some practical problems.

Course 305 **Periods: T-1, W-1**

OTTO GLASSER, Cleveland, Ohio

Roentgen-Ray Physics

The following subjects will be discussed:

Structure of matter.

Subatomic particles; electron, proton, neutron, deutron, etc.

Nature of radiation, corpuscular and electromagnetic.

Fundamental electrical conceptions.

Production of roentgen rays; high tension generator and roentgen tubes.

Radium: alpha, beta, and gamma rays.

Interaction of radiation and matter.

Various effects of radiation.

Ionization.

Scattered, secondary and characteristic radiation.

Course 306 **Periods: T-2, W-2**

FRED M. HODGES, Richmond, Va.

Roentgen Treatment of Inflammatory Lesions

This course will discuss the roentgen treatment of the following conditions: acne, furunculosis, carbuncle, granuloma, some fungus infections, erysipelas, various localized types of cellulitis, pruritus ani, infected rhinophyma, Mikulicz's disease.

The technique, which in our experience, has given the best results in these various conditions will be thoroughly discussed.

Course 307 **Periods: Th-2, F-2**

JAMES F. KELLY, Omaha, Nebr.

The Use of the Mobile Roentgen Therapy Unit in Infections

The mobile therapy unit opens up to the radiologist a vast field of therapy which is practically unexplored. He can now treat the serious infections as his judgment dictates without the hazard of moving the patient. This should create new interest and better methods.

Experiences in treating gas gangrene, peritonitis, surgical mumps, erysipelas, Ludwig's angina, pneumonia, carbuncles, mastoiditis, and other infections with this type of apparatus will be discussed from the technical and clinical angles.

The excellent results secured and the harmlessness of this type of therapy as compared with other dangerous and experimental practices now currently used as well as the possibility of using the roentgen ray as a prophylactic measure will also be considered.

Course 308 **Periods: Th-2, F-2**

T. LEUCUTIA, M.D., Detroit, Mich.
K. E. CORRIGAN, Ph.D., Detroit, Mich.

Comparison of 200 kv. and Supervoltage Roentgen Therapy

I. *Physical Aspect.* Supervoltage roentgen therapy differs from the 200 kv. therapy at least on three points:

1. There is an increase in the differential action of the roentgen rays with increasing voltages, whether this action be a direct or indirect function of the quality of the roentgen rays.
2. An increasingly larger physical dose of radiation can be administered with increasing voltages to produce a similar biologic effect, especially skin erythema.
3. The percentage depth dose, in addition to certain other deviations, shows an appreciable increase with higher voltages.

II. *Clinical Aspect.* In estimating the clinical value, one may distinguish between the immediate effect and late results:

1. The immediate effect is superior with supervoltage roentgen therapy in a well selected group of malignant neoplasms: (*a*) due to the fact that because of the above physical factors, the radiation is more homogeneous and efficacious, and (*b*) since a larger total dose can be administered with a lesser damage to the skin.
2. The late results are dependent on a good immediate effect and on a relatively low malignancy index of the irradiated neoplasm, so that the tumor remains local. Five-year statistical data are given.

Course 309 **Periods: T-2, W-2**

CHARLES L. MARTIN, Dallas, Texas

Radiation Treatment of Pharyngeal Carcinoma

Carcinoma of the pharynx comes on very insidiously and imitates many other diseases such as Hodgkin's disease, brain tumor, tonsillitis, and disorders of the internal ear. Photographs, roentgenograms and charts will be presented illustrating the various types of metastases, especially those which pass through the floor of the skull and into the neck producing involvement of practically all of the cranial nerves.

The good results obtained when the primary lesions are treated with multiple doses of roentgen rays will be illustrated with actual cases, and the care of extensions to the skull, neck and thorax will be discussed. Most of the failures have resulted from the appearance of distant metastases after the cure of the primary tumors. A plan for preventing such late complications will be described.

Course 310 **Periods: Th-2, F-2**

CHARLES L. MARTIN, Dallas, Texas

Radiation Treatment of Cervical Metastases

This demonstration will deal only with metastases in the cervical lymph nodes secondary to squamous cell carcinoma arising in the mouth and lip and on the face. Neither surgery nor irradiation have produced many cures in proven cases. The best irradiation results have, in the past, been obtained by implanting radon seeds in individual nodes at operation. This method often fails because it does not distribute effective radiation over all of the involved lymphatic area. The technique of a new plan combining the implantation of multiple long, weak, radium needles and external roentgen irradiation will be described. This procedure tends to do what a block dissection is designed for. Photographs of many treated cases will be shown to demonstrate the effectiveness of the procedure as well as some of its disadvantages.

Course 311 **Periods: Th-2, F-2**

WILLIAM S. NEWCOMET, Philadelphia, Pa.

Radium Therapy of Hemangiomata

Early methods used in the treatment of hemangiomata.

The application of roentgen and radium radiation, the differences between them.

Varieties of hemangiomata from the standpoint of the pathologist, dermatologist, surgeon and radiologist.

Possibility of malignant degeneration.

Spontaneous ulceration and ulceration occurring during treatment. Other complications, local lack of growth, dermatitis local and general, telangiectasis and lack of function of affected part.

Discussion of treatment in the young infant, child and adult.

General review of groups and individual cases.

Results observed immediately after treatment and ten to twenty years later.

Course 312 **Periods: T-2, W-2**

G. E. PFAHLER, Philadelphia, Pa.

Radiation Treatment of Cancer of the Breast

The technique for the treatment of cancer of the breast cannot be standardized. The treatment will be demonstrated for cancer of the breast in various stages, including positioning of patient for treatment.

There will also be a demonstration of some of the cases treated primarily and completely by irradiation, also preoperative and postoperative irradiation, including the management of recurrences.

Course 313 **Periods: T-1, W-1**

DOUGLAS QUICK, New York City

Treatment of Metastatic Cervical Nodes from Primary Epidermoid Carcinoma of the Upper Mucous Membrane Tract

The problem will be considered under the following headings:

1. General considerations leading up to the present plan.
2. External irradiation, its place, and technical manner of delivery.
3. Surgical dissection of the neck.
4. Interstitial irradiation, preferential method, and technique.
5. Palliative therapy.

Course 314 **Periods: T-2, W-2**

EDITH H. QUIMBY, New York City

Roentgen-Ray Dosage

For a complete statement of roentgen-ray dosage it is necessary to know the amount of radiation de-

livered in air, in the skin at the port of entry, at the lesion, and in the skin at the port of exit. Methods of determining and specifying these doses will be considered. Their relation to the various physical factors of the roentgen-ray set-up will be discussed and data presented for practical use.

Course 315 **Periods: Th-1, F-1**

ROBERT B. TAFT, Charleston, S. C.

Dosage Measurement from a Clinical Standpoint

The author proposes to describe briefly and show photographs of all the methods in use today for roentgen-ray measurement, stating the advantages and disadvantages of each. Illustrations should be obtainable from manufacturers, which will be shown as lantern slides. The value of the "roentgen" as a clinical unit will be discussed and mention of the proposed unit, the "duane" will be made. Pros and cons for the direct dosage measurement on the skin of the patient throughout the treatment time will be given. Air measurements versus skin measurements will be outlined and tables given for back-scattering at commonly used wave lengths. Half of the period will be taken up with the above and round table discussion will follow. Throughout all, an earnest effort will be made to keep the matter within the scope of the clinical radiologist who has little knowledge of, or interest in, pure physical measurements. The author, having had some experience in both clinical and physical work, will attempt to narrow the far-too-wide gap between the clinician and physicist. A typed summary will be available to those attending.

Course 316 **Periods: T-1, W-1**

LAURISTON S. TAYLOR, Washington, D. C.

The Measurement of Quantity and Quality of Roentgen Rays

A general discussion, aimed at showing the necessity for roentgen-ray quantity and quality measurements, will be presented. A brief outline of the fundamental principles involved in the application of roentgen-ray standards will be given. A few examples of actual cases involving the application of physical dosage measurement will be carried through. Likewise the method of determining an absorption curve will be illustrated and the information obtainable therefrom discussed. No discussion of tissue dosage or related subjects will be given.

Course 317 **Periods: T-1, W-1**

CHARLES A. WATERS, Baltimore, Md.

Radiation Treatment of Renal Tumors

The author will discuss (1) a brief differential diagnosis of renal tumors as related to roentgen diagnosis and treatment; (2) previous statistics on the curability of renal tumors without the aid of preoperative irradiation; (3) the immediate effects of radiation upon the various types of renal tumors; (4) the dangers, pitfalls, and contraindications of irradiation; (5) a discussion of elapsed time between the radiation therapy and operative removal, and (6) the results in preoperative irradiated cases as compared to non-preoperative irradiated cases.

Course 318 **Periods: Th-2, F-2**

J. L. WEATHERWAX, Philadelphia, Pa.

Radium Dosage

A brief discussion of the disintegration cascade of radium; active deposit; differentiation of radium compared to radium emanation or radon; absorption by different filters and thicknesses of filter; half-life and average life of radon; types of radium applicators; interstitial irradiation; expression of dosage in terms of milligram-hours, millicurie-hours; millicuries-destroyed and a discussion of an attempt to express dosage in roentgens.

An outline will be furnished with a bibliography.

Course 319 **Periods: Th-1, F-1**

B. P. WIDMANN, Philadelphia, Pa.

Radiation Therapy in Cancer of the Skin

Technical procedures for the radium and roentgen treatment of cancer of the skin will be reviewed and analyzed in detail. A definite predetermined plan of dosage has been formulated according to the estimated surface area and thickness of the lesion. Special emphasis will be placed on the value of low voltage roentgen rays (100–135 kv.), and a clinical comparison with radium will be made according to a great variety of patterns for single and multiple radium tubes with different sizes of fields, filters and distances. Conclusions will be drawn from a large clinical experience with massive and fractional doses. Determinations of the "maximum safe dose," the "minimal effective dose," the daily intensity and the probable best rate of administration will be considered with specific recommendations after a routine experience demonstrating results and skin tolerance.

CONDENSED SCHEDULE OF COURSES

Code: T-1 **1st Period: 2:00 to 3:15**

TUESDAY

Diagnostic Roentgenology

201—Archer Bogart	Chest Findings in "Country Diseases"
207—Carty	Soft Tissue Roentgenography
210—Dyke	Normal Encephalogram and Ventriculogram
216—P. C. Hodges Davis	Roentgen Pelvimetry and Fetometry
223—Potter	Roentgen Diagnosis of Silicosis
225—Sante	Bronchial Occlusion
227—Scott	Technique and Clinical Application of Kymographic Studies of the Heart

Code: T-1 **1st Period: 2:00 to 3:15**

TUESDAY

Therapeutic Radiology

Miscellaneous and Sequential Courses

A—Murphy Morse	Radiologic-Pathologic Conference on Bone Tumors
302—Desjardins	Lymphoblastoma
303—Ernst	Practical Concepts of Radiation Treatment of Cancer of the Cervix Uteri
305—Glasser	Roentgen-Ray Physics
313—Quick	Radiation Treatment of Neck Metastases
316—Taylor	Measurement of Quantity and Quality of Roentgen Rays
317—Waters	Radiation Treatment of Renal Tumors

Code: T-2 **2nd Period: 3:15 to 4:30**

TUESDAY

Diagnostic Roentgenology

205—Bromer	Differential Diagnosis of Skeletal Changes in Diseases of Children
208—Chamberlain	Technique and Interpretation of Oxygen Myelography
213—Golden Swenson	Diseases of the Small Intestine
214—Hampton	Technique and Interpretation of Lateral Chest Roentgenography
218—Lockwood	Secondary Tumors of the Lung and Their Roentgenologic Manifestations
221—Nichols	Retrograde Pyelography
222—Peirce	Differential Diagnosis of Nontuberculous Lesions of the Lung
229—Weber	Technique and Application of Methods of Examining the Large Intestine

Code: T-2 **2nd Period: 3:15 to 4:30**

TUESDAY

Miscellaneous and Therapeutic Radiology

103—Wasson	Anatomy of the Lungs
306—F. M. Hodges	Roentgen Treatment of Inflammatory Lesions
309—Martin	Radiation Treatment of Pharyngeal Carcinoma
312—Pfahler	Radiation Treatment of Cancer of the Breast
314—Quimby	Roentgen-Ray Dosage

TIME OF PERIODS

1st Period..... 2:00 to 3:15 P.M.
2nd Period..... 3:15 to 4:30 P.M.

ORDER SHEET

It is important that those wishing to attend the instruction courses should register as early as possible in view of the fact that the number admitted to each course will be limited. Reservations will be made in the order of the receipt of this order sheet. *It is therefore important that you list your first, second and third choice for each period.*

Non-members will pay $1.00 for each period or a maximum of $5.00 for five or more periods. *Non-members' fees should accompany this order sheet.*

Fill out the following (type or print)

..... Last Name First Name or Initials

..... Street Address

..... City State

Check ☐ Member ☐ Candidate for Membership—1939 ☐ Guest

(over)

SPECIAL CONTINUOUS COURSE

This is a 4-period sequential course

Course	Lecturer	Periods given	Indicate if you wish to register for this course
A	Murphy and Morse	T-1, W-1, Th-1, F-1	

Please note that if you register for the above course you can register for only one additional single period course each day.

FOR CONVENIENCE IN SELECTING YOUR COURSES CONSULT THE CONDENSED SCHEDULE ON THE FOLLOWING PAGES.

SINGLE PERIOD COURSES

Each of these courses except No. 103 is repeated once so do not sign up for more than one period in any one course.

Period	First Choice		Second Choice		Third Choice	
	Course No.	Lecturer	Course No.	Lecturer	Course No.	Lecturer
Tues. 1						
Tues. 2						
Wed. 1						
Wed. 2						
Thurs. 1						
Thurs. 2						
Fri. 1						
Fri. 2						

Mail this order sheet to Dr. B. R. Kirklin, Mayo Clinic, Rochester, Minn.

CONDENSED SCHEDULE OF COURSES

Code: W-1 **1st Period: 2:00 to 3:15**

WEDNESDAY

Diagnostic Roentgenology

201—Archer Bogart	Chest Findings in "Country Diseases"
207—Carty	Soft Tissue Roentgenography
210—Dyke	Normal Encephalogram and Ventriculogram
216—P. C. Hodges Davis	Roentgen Pelvimetry and Fetometry
223—Potter	Roentgen Diagnosis of Silicosis
225—Sante	Bronchial Occlusion
227—Scott	Technique and Clinical Application of Kymographic Studies of the Heart

Code: W-1 **1st Period: 2:00 to 3:15**

WEDNESDAY

Therapeutic Radiology

Miscellaneous and Sequential Courses

A—Murphy Morse	Radiologic-Pathologic Conference on Bone Tumors
302—Desjardins	Lymphoblastoma
303—Ernst	Practical Concepts of Radiation Treatment of Cancer of the Cervix Uteri
305—Glasser	Roentgen-Ray Physics
313—Quick	Radiation Treatment of Neck Metastases
316—Taylor	Measurement of Quantity and Quality of Roentgen Rays
317—Waters	Radiation Treatment of Renal Tumors

Code: W-2 **2nd Period: 3:15 to 4:30**

WEDNESDAY

Diagnostic Roentgenology

205—Bromer	Differential Diagnosis of Skeletal Changes in Diseases of Children
208—Chamberlain	Technique and Interpretation of Oxygen Myelography
213—Golden Swenson	Diseases of the Small Intestine
214—Hampton	Technique and Interpretation of Lateral Chest Roentgenography
218—Lockwood	Secondary Tumors of the Lung and Their Roentgenologic Manifestations
221—Nichols	Retrograde Pyelography
222—Peirce	Differential Diagnosis of Nontuberculous Lesions of the Lung
229—Weber	Technique and Application of Methods of Examining the Large Intestine

Code: W-2 **2nd Period: 3:15 to 4:30**

WEDNESDAY

Miscellaneous and Therapeutic Radiology

103—Wasson	Physiology and Mechanics of the Chest and particularly of the Lungs.
306—F. M. Hodges	Roentgen Treatment of Inflammatory Lesions
309—Martin	Radiation Treatment of Pharyngeal Carcinoma
312—Pfahler	Radiation Treatment of Cancer of the Breast
314—Quimby	Roentgen-Ray Dosage

Be sure to select courses so that there will be no conflict in time.

CONDENSED SCHEDULE OF COURSES

Code: Th-1 **1st Period: 2:00 to 3:15**

THURSDAY

Diagnostic Roentgenology

203—Austin	Interpretation of the Dental Roentgenogram
204—Bishop	Examination and Diagnosis of Lesions of the Temporomandibular Joint
206—Camp	Opaque Oil Myelography
215—Hatcher P. C. Hodges	Surgical, Roentgenological and Pathological Findings in Certain Bone Lesions
220—Nichols	Excretory Urography
224—Rigler	Roentgen Diagnosis of Pleural Effusions
228—Sosman	Pituitary Adenomas: Diagnosis, and Treatment by Irradiation

Code: Th-1 **1st Period: 2:00 to 3:15**

Thursday

Therapeutic Radiology

Miscellaneous and Sequential Courses

A—Murphy Morse	Radiologic-Pathologic Conference on Bone Tumors
102—F. J. Hodges I. Lampe	Filing and Cross-indexing Roentgen-Ray Records
301—Bowing	Radiation Treatment of Carcinoma of the Cervix Uteri
304—Failla	Some Aspects of Radiosensitivity
315—Taft	Dosage Measurement from a Clinical Standpoint
319—Widmann	Radiation Therapy in Cancer of the Skin

Code: Th-2 **2nd Period: 3:15 to 4:30**

THURSDAY

Diagnostic Roentgenology

202—Archer	Roentgenologic Manifestations in Osteomyelitis
209—Doub	The Intervertebral Disc
211—Dyke	Pneumo-encephalographic Diagnosis of Brain Tumor
212—Farrell	Roentgen Diagnosis of Lesions of the Esophagus
217—Kornblum	Tumors about the Sella Turcica
219—Moore	Technique and Clinical Application of Body Section Roentgenography
226—Schatzki	Roentgen Diagnosis of Gastritis

Code: Th-2 **2nd Period: 3:15 to 4:30**

THURSDAY

Miscellaneous and Therapeutic Radiology

101—Gershon-Cohen	The Physiology of the Stomach
103—Wasson	The Classification of Diseases of the Lungs
307—Kelly	The Use of the Mobile Roentgen-Ray Therapy Unit in Infections
308—Leucutia Corrigan	Comparison of 200 kv. and Supervoltage Roentgen Therapy
310—C. L. Martin	Radiation Treatment of Cervical Metastases
311—Newcomet	Radium Therapy of Hemangiomata
318—Weatherwax	Radium Dosage

CONDENSED SCHEDULE OF COURSES

Code: F-1 **1st Period: 2:00 to 3:15**

FRIDAY

Diagnostic Roentgenology

203—Austin	Interpretation of the Dental Roentgenogram
204—Bishop	Examination and Diagnosis of Lesions of the Temporomandibular Joint
206—Camp	Opaque Oil Myelography
215—Hatcher P. C. Hodges	Surgical, Roentgenological and Pathological Findings in Certain Bone Lesions
220—Nichols	Excretory Urography
224—Rigler	Roentgen Diagnosis of Pleural Effusions
228—Sosman	Pituitary Adenomas: Diagnosis, and Treatment by Irradiation

Code: F-1 **1st Period: 2:00 to 3:15**

FRIDAY

Therapeutic Radiology

Miscellaneous and Sequential Courses

A—Murphy Morse	Radiologic-Pathologic Conference on Bone Tumors
102—F. J. Hodges I. Lampe	Filing and Cross-indexing Roentgen-Ray Records
301—Bowing	Radiation Treatment of Carcinoma of the Cervix Uteri
304—Failla	Some Aspects of Radiosensitivity
315—Taft	Dosage Measurement from a Clinical Standpoint
319—Widmann	Radiation Therapy in Cancer of the Skin

Code: F-2 **2nd Period: 3:15 to 4:30**

FRIDAY

Diagnostic Roentgenology

202—Archer	Roentgenologic Manifestations in Osteomyelitis
209—Doub	The Intervertebral Disc
211—Dyke	Pneumo-encephalographic Diagnosis of Brain Tumor
212—Farrell	Roentgen Diagnosis of Lesions of the Esophagus
217—Kornblum	Tumors about the Sella Turcica
219—Moore	Technique and Clinical Application of Body Section Roentgenography
226—Schatzki	Roentgen Diagnosis of Gastritis

Code: F-2 **2nd Period: 3:15 to 4:30**

FRIDAY

Miscellaneous and Therapeutic Radiology

101—Gershon-Cohen	The Physiology of the Stomach
103—Wasson	Roentgenologic Diagnosis of Diseases of the Lungs.
307—Kelly	The Use of the Mobile Roentgen-Ray Therapy Unit in Infections
308—Leucutia Corrigan	Comparison of 200 kv. and Supervoltage Roentgen Therapy
310—C. L. Martin	Radiation Treatment of Cervical Metastases
311—Newcomet	Radium Therapy of Hemangiomata
318—Weatherwax	Radium Dosage

BULLETIN OF THE INTER-SOCIETY COMMITTEE FOR RADIOLOGY

POINTS OF INTEREST

In drawing up plans for state-wide group hospitalization in *Michigan*, the following definition was established by the Michigan State Medical Society and the Michigan Hospital Association:

It is agreed that the professional services of a doctor of medicine shall not be included in group hospital service programs. Technical services may be rendered as hereinafter defined: Technical services, in connection with hospital and medical service plans, are not considered professional medical services unless rendered directly by a doctor of medicine. Notwithstanding the above definition, it is agreed that the hospital program will not include any x-ray service.

* * *

On February 14 the Board of Trustees of the *American Medical Association* held a joint meeting in Chicago with representatives of the American Hospital Association. Purpose of the meeting was to seek solutions for some of the conflicts which seem to have developed between the organized hospital world and the organized medical profession in recent years, and to weld a bond of unity between the two allied groups. Resolutions adopted at the close of the meeting provided for similar meetings in the future and gave reason to hope for greater understanding and mutual support between hospitals and the medical profession.

* * *

Associated Hospital Service of *New York*, the largest group hospitalization plan in the country, and one which includes among its benefits, certain medical services as a part of hospital care, suddenly announced a sharp reduction in payments to participating hospitals last month. Payments to hospitals which formerly amounted to $15.00 for the first day of hospitalization and $20.00 for the second day, were reduced to $11.25 and $15.00 respectively. It is interesting to observe that the group hospitalization plan in Washington, D. C., which confines its benefits to hospital accommodation as recommended by the American Medical Association, was able last year to decrease its premium by 13 per cent and at the same time increase the number of days of hospital care provided.

The hospital insurance plan in Boston which recently added radiology to its benefits with the allegation that mounting reserves warranted the extension of services, found it necessary to reduce its payments at the same time.

* * *

A state cancer hospital, built with WPA and state tax funds is nearing completion in *Columbia, Missouri*. It is being built at a cost of $500,000. Beds will accommodate 90 patients. In addition, a clinic will be provided at the hospital to provide care for ambulatory cases.

* * *

At the request of a special committee of the State Medical Society, the *Kansas* Board of Medical Registration and Examination asked its attorney for an opinion concerning the right of non-medical practitioners to engage in the practice of radiology, either diagnostic or therapeutic. The following opinion was transmitted to the Board on April 7:

It is my opinion, based upon a careful study of the statutes and the Supreme Court opinions that roentgenology, either diagnostic or therapeutic, constitutes a practice of medicine and surgery as defined by the statutes of Kansas. Such practice when carried on by one not licensed to practice medicine and surgery is prohibited and unlawful.

No rule of your Board can change these provisions of the statutes. Your Board could not, by rule, permit one not licensed as an M.D. to practice either branch of roentgenology, even if such practice was carried on under the direction of an M.D. The Board can not by rule, modify a statutory enactment. There may be, and undoubtedly are, certain technical operations connected with the practice of roentgen-

ology that can be carried on by an unlicensed technician. Those operations, of course, could not include diagnostic or therapeutic work.

In consequence of this opinion, the Committee enacted the following resolution which was forwarded to the State Board of Medical Registration and Examination with the request that the board adopt it as a part of its rules and regulations governing the practice of medicine in Kansas:

Be It Hereby Resolved, That roentgenology, both diagnostic and therapeutic is a specialized and technical branch of the practice of medicine, which in unskilled hands might be dangerous, and while it is recognized there is a need for lay x-ray technicians as a means of assistance to the physician, these technicians should work only under the direct supervision of a doctor of medicine.

Be It Further Resolved, That it is the consensus of the committee that all x-ray therapy should be administered under the personal supervision of a doctor of medicine.

* * *

The executive secretary of the Inter-Society Committee for Radiology attended the regular meeting of the *Georgia Radiological Society* in Columbus on March 28. The Society adopted a resolution calling upon the Georgia State Medical Society to take stringent action against hospitals in the state which were engaging in the corporate practice of medicine.

Georgia radiologists maintain an active and sustained program in the field of medical economics through their state radiological society. Recently they were successful in securing an amendment to the state cancer law which permits private radiologists to treat state-aid patients. Formerly this work was confined to institutions.

Efforts are now being made to correct the state crippled children's law to provide a method for reimbursing radiologists who perform services on these patients. Fees for radiological services are now included in a per diem payment to approved hospitals.

As in other places, Georgia has had its troubles with hospital insurance. Repeated attempts have been made to install a group hospitalization plan which included radiology as a part of hospital care. The state society has not been idle, however, and at the present writing no such plan has been inaugurated. Dr. James J. Clark is president.

* * *

The *Florida Radiological Society* held a special meeting on March 19, at Orlando, which was attended by the executive secretary of the Inter-Society Committee for Radiology. The Florida society is an active one and much has been accomplished during the last year or two in protecting and advancing the specialty in that state.

Repeated attempts have been made in several localities to add radiology as a hospital service to group hospitalization plans. Through the efforts of the Florida Radiological Society and with the full support of the county medical societies in the respective communities, these attempts have been defeated. Dr. H. O. Brown is president.

* * *

Current reports indicate that the *Wagner Health Bill* will probably not reach the floor of the Senate at this session of Congress but will remain in the hands of the Senate Committee on Education and Labor until some sebsequent date. A wave protest from physicians concerning certain features of the bill in its relation to the medical profession and the public health makes it all the more probable that the bill will be substantially changed before it is brought before the Senate.

The Inter-Society Committee issued a special bulletin to all members of the four national societies on April 6 in regard to the Bill.

* * *

Anent the Vincent Bill introduced in the *New York* Legislature to prohibit the practice of radiology by laymen, the *New York Medical Week* published the following editorial comment in its issue of March 11:

Those branches of medicine which employ nonmedical technicians are most susceptible to lay encroachment. This is notably true in radiol-

ogy, physical therapy and clinical pathology Lay technicians, dazzled by their ability to carry out certain routine procedures, forget they are not qualified to relate their findings to the human body. Laboratories operated by laymen attempt to diagnose, and in some cases treat, disease in violation of the letter and spirit of the Medical Practice Act.

A bill sponsored by Assemblyman Vincent makes a direct and effective attack on the practice of radiology by unqualified persons. It requires radiological laboratories to obtain a municipal permit to operate and limits the issuance of such permits to physicians, dentists and osteopaths. To prevent terminological controversies, it defines radiology as the diagnosis or treatment of disease by exposure to radium or roentgen rays.

The Vincent Act leaves no loopholes for quacks who like to practice with a semblance of legality. By explicitly defining radiology and limiting its practice to physicians, dentists and osteopaths, it effectively bars this important specialty to laymen with a degree of technical skill but insufficient knowledge of medical science to practice independently.

* * *

Dr. Arthur W. Erskine, President of the *Iowa State Medical Society*, arranged for radiological representatives to be present at a meeting on April 11, when the Iowa Hospital Association drew up plans for a state-wide group hospitalization plan. The plan was formally approved and adopted at a meeting on April 24. Benefits are confined to hospital accommodations; radiology, anesthesia and pathology are excluded.

* * *

At the annual meeting of the American Medical Association in San Francisco the House of Delegates directed the *Council on Medical Education and Hospitals*, together with the Bureau of Medical Economics, to draw up certain standards governing the practice of radiology, pathology, and anesthesia, as well as other medical services, in hospitals. Subsequently a special committee of the American College of Radiology, in collaboration with the Inter-Society Committee, began the preparation of a "Manual of Desirable Standards for Hospital Radiological Departments." Dr. Vincent W. Archer is chairman of the College committee.

Tentatively completed, the Manual was submitted to the Council on Medical Education and Hospitals by the joint Committee at a meeting between the Inter-Society Committee and the Council during the St. Louis session. When finally agreed upon, the Committee hopes to have the official approval of the Council for the Manual. It will be printed to serve as a reference work for hospital administrators, radiologists, and others.

In discussing the Manual the joint Committee raised the question of the "Essentials for a Registered Hospital," used by the Council in approving hospitals. Section 7 of the "Essentials" now reads as follows:

7. RADIOLOGY.—The hospital should provide or have ready access to radiological equipment and service. When a full time or part time physician-roentgenologist cannot be employed, the services of such a consultant should be secured. Radiologic interpretations must be made only by a competent roentgenologist. A description of the roentgenologic examinations should be placed in the patient's chart. The physician-roentgenologist preferably should be one who is a diplomate of the American Board of Radiology or a physician whose qualifications are acceptable to the Council on Medical Education and Hospitals of the American Medical Association.

At the request of the Committee, the Council has revised Section 7, subject to approval by the House of Delegates, as follows:

7. RADIOLOGY—*The responsibility for all radiologic examinations must rest on the physician-roentgenologist who is head of the department.* His findings and conclusions for all examinations should be placed in the patient's chart. Nothing in this provision should preclude additional study and interpretations by qualified attending physicians on the staff.

The physician-roentgenologist should be preferably one who is a diplomate of the American Board of Radiology or a physician whose qualifications are acceptable to the Council on

Medical Education and Hospitals of the American Medical Association.

It shall not be the policy of the hospital to make a profit from the department of radiology.

* * *

In refusing to review a decision of the *California* Supreme Court against the Pacific Health Corporation, the United States Supreme Court has again reaffirmed the doctrine that a corporation may not practice medicine. In rendering its decision the California Supreme Court ruled that the law forbidding the corporate practice of medicine applied to eleemosynary institutions as well as to commercial enterprises. It was held that a corporation may not circumvent the law by hiring licensed physicians to render the actual medical service. By its action the Supreme Court of the United States leaves little room for debate about the legality of a corporation employing physicians to practice medicine.

Mac F. Cahal
Executive Secretary

AMERICAN RADIUM SOCIETY

At the twenty-fourth annual meeting of the American Radium Society held at the Hotel Jefferson, St. Louis, Missouri, on May 15 and 16, 1939, the following officers were elected: *President*, Dr. Lawrence A. Pomeroy, Cleveland, Ohio; *President-Elect:* Dr. Frederick W. O'Brien, Boston, Mass.; *1st Vice-President:* Dr. Hayes E. Martin, New York City; *2nd Vice-President:* Dr. Eugene T. Leddy, Rochester, Minn.; *Secretary*, Dr. William E. Costolow, Los Angeles, Calif.; *Treasurer*, Dr. Charles L. Martin, Dallas, Texas. The next annual meeting will be held in New York City in 1940.

AMERICAN COLLEGE OF RADIOLOGY

At the meeting of the American College of Radiology held in St. Louis, Missouri, on May 17, 1939, the following officers were elected: *President*, Dr. Fred M. Hodges, Richmond, Virginia; *Vice-President*, Dr. J. C. Dickinson, Tampa, Florida; *Treasurer*, Dr. E. L. Jenkinson, Chicago; *Secretary*, Mac F. Cahal, Chicago. The next annual conference of the College will be held at the Palmer House, Chicago, in February, 1940. The next annual meeting will be held in New York City on June 12, 1940.

GOLF TOURNAMENT

The second annual Willis F. Manges Memorial Golf Tournament will be held the day before the opening of the meeting of the American Roentgen Ray Society, at the Flossmoor Country Club on Monday, September 18, 1939. This event is open to all members of the Society, manufacturers and guests. The course will be open for all day play. Numerous prizes will be awarded. Those who do not play golf are invited to attend the evening dinner at the Club. Train transportation is convenient and frequent. Details will be announced later and further information may also be obtained from Dr. M. J. Hubeny, Cook County Hospital, Chicago, Illinois.

FLORIDA RADIOLOGICAL SOCIETY

The Spring Meeting of the Florida Radiological Society was held at the Princess Issena Hotel, Daytona Beach, Florida, May 1 and 2, 1939. One session was devoted to study of case histories illustrated by films; another session to therapeutic problems affecting radiology. The officers for the ensuing year are: *President*, Dr. H. B. McEuen, Jacksonville; *Vice-President*, Dr. Joseph H. Lucinian, Miami; *Secretary-Treasurer*, Dr. John N. Moore, 210 Professional Building, Ocala, Florida. Meetings are held in November, and at the annual meeting of the Medical Association of Florida in the spring.

KENTUCKY RADIOLOGICAL SOCIETY

A meeting of the radiologists of Kentucky was held at the Brown Hotel in Louisville on Saturday afternoon, April 29, 1939, and the Kentucky Radiological Society was organized. The following officers

were elected: *President*, Dr. D. B. Harding, Lexington; *Vice-President*, Dr. I. T. Fugate, Louisville; *Secretary-Treasurer*, Dr. Joseph C. Bell, Louisville. Meetings will be held annually in Louisville on the third Sunday afternoon in April. A dinner was served after the business meeting and following this Dr. Raymond C. Beeler and Dr. James N. Collins of Indianapolis spoke to the Society concerning the work of the Indiana Roentgen Society.

MIDSUMMER RADIOLOGICAL CONFERENCE

The Fifth Midsummer Radiological Conference in the Rocky Mountains, sponsored by the Denver Radiological Club, will be held in Denver, Colorado, on July 27, 28 and 29, 1939. Headquarters will be the Hotel Shirley Savoy. Further information may be obtained from Dr. L. G. Crosby, 366 Metropolitan Building, Denver.

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DEPARTMENT OF TECHNIQUE

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A METHOD OF CALIBRATING ROENTGENOGRAPHIC MACHINES

By HENRY RANDALL, B.A., M.S., *and* LAWRENCE F. BLACK
WASHINGTON, D.C.

A DEVICE is proposed for calibrating roentgen-ray machines for roentgenographic work. It is as accurate as the usual methods, is simple to use, and can be used with the shockproof, all enclosed equipment. This equipment is becoming more common, and a sphere gap is not satisfactory for use with it. The proposed method employs the familiar density comparisons of exposures on roentgen films.

No effort has been made to prepare a bibliography. The method is a combination of ideas which have long been common in the field. It is offered because it is believed it has advantages in the following respects:

1. Greater accuracy than the sphere gap.
2. Apparatus required is relatively simple, certainly less expensive and complicated than a sphere gap.
3. It can be used with shockproof equipment.
4. Its use does not involve attachments to the roentgen-ray machine.
5. The results obtained permit roentgenographic comparison between different installations regardless of wave shape and peaks. They permit the transfer of roentgenographic technique from one machine to another with the minimum of factor juggling.
6. Findings can be duplicated.

The device consists of an aluminum block 5 by 5 inches by $\frac{3}{4}$ inch thick; two round lead diaphragms measuring $4\frac{1}{2}$ inches in diameter and $\frac{1}{8}$ inch thick. One of these diaphragms has a 45° window, 2 inches from the center, radial width of 1 inch. The second diaphragm is a lead ring $4\frac{1}{2}$ inches in diameter with a 2 inch hole in the center, $\frac{1}{8}$ inch lead. Two copper filters measuring 5 by 5 inches by 0.5 mm. thick, and the usual double screen cassette, film markers, and a thick lead cover for one-half of an 8″×10″ cassette. To use this device one-half of the film is exposed with a series of exposures on a machine whose calibration is known, let it be kilovolts (peak), pre-reading volts or buttons. (It is to be noted that the accuracy of determination of the calibration of the "known" machine is not necessarily vital. The final results will be in terms of this machine and can be used for exact duplication of roentgenographic work, regardless of the actual kilovoltage of either machine.) These known exposures form an eight segment circle with the center left blank. Then the diaphragm and the entire device is moved to the machine to be calibrated and the center exposed on the unknown machine at the approximate voltage. The film is then developed by standard methods, and the exposure of the center section can be matched with one of the outer exposures exactly. Three exposures of this type are enough to chart the average machine for any milliamperage.

The authors have used the following technique with good results:

Voltage Range (2 kv. (peak) steps)	Distance inches	Ma-Sec.	Additional Filtration
30 to 44 kv. (peak)	20	100	None
44 to 58 kv. (peak)	30	30	None
60 to 74 kv. (peak)	60	60	0.5 mm. Cu
76 to 90 kv. (peak)	60	30	1.0 mm. Cu

All exposures were made with intensifying screens in cassettes, which produces a more satisfactory contrast scale, particu-

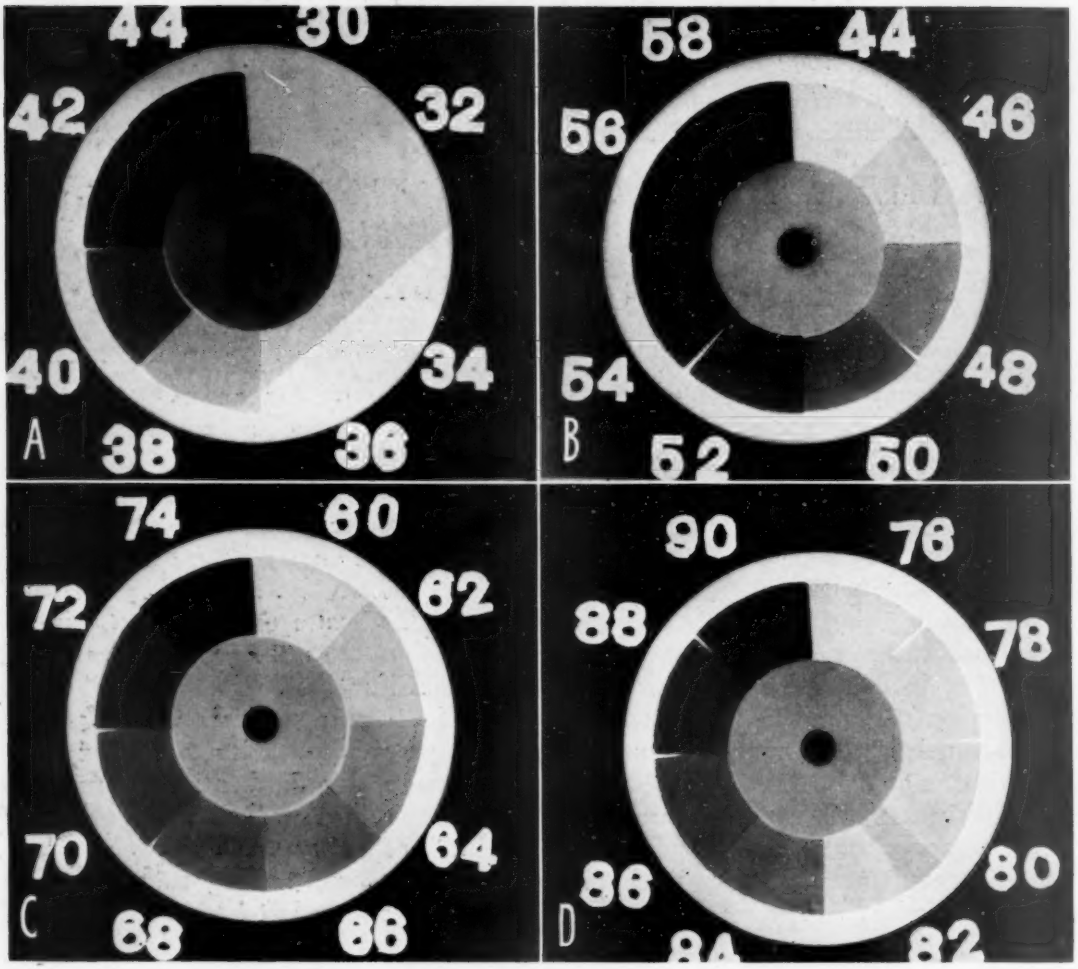

FIG. 1. *A*, numbers outside segments represent the kilovolts used to produce these various densities at 20 inches, with 100 ma-sec. The large center disk is the density obtained from the second machine at an unknown kilovoltage at 20 inches and 100 ma-sec. By matching densities we find the unknown to be equal to 40 kv. (peak) without question.

B, these are the densities obtained with the indicated kilovoltage at a distance of 30 inches using 30 ma-sec. The center matches the 48 kv. segment, thus the unknown kilovoltage is equal to 48 kv.

C, these densities were obtained with a kilovoltage range of 60 to 74 kv. (peak) through an added filter of 0.5 mm. copper, with the following factors: distance 60 inches; milliampere-seconds 60. The unknown in the above is 66 kv. (peak).

D, this film shows a range of 76 to 90 kv. (peak) through an additional filter of 1 mm. of copper with the following factors: 60 in. distance and 30 ma-sec. The unknown in the above is 84 kv. (peak)

larly at higher ranges. If the standard machine is not always near at hand, several films can be exposed, removed, and replaced again in the casette when needed.

The filtration used is up to the user. We tried to approximate the working conditions of an interposed body. With this in mind, the aluminum block of approximately 2 cm. was chosen as a base. The aluminum block alone was used for lower voltages, 30 to 58 kv. (peak). One-half millimeter of copper was added to the aluminum block for voltages from 60 to 74 kv. (peak). Better contrast was obtained in the voltage range of 76 to 90 kv. (peak), when 1 mm. of copper was placed under the aluminum block. The kilovoltage increment between steps was taken as 2

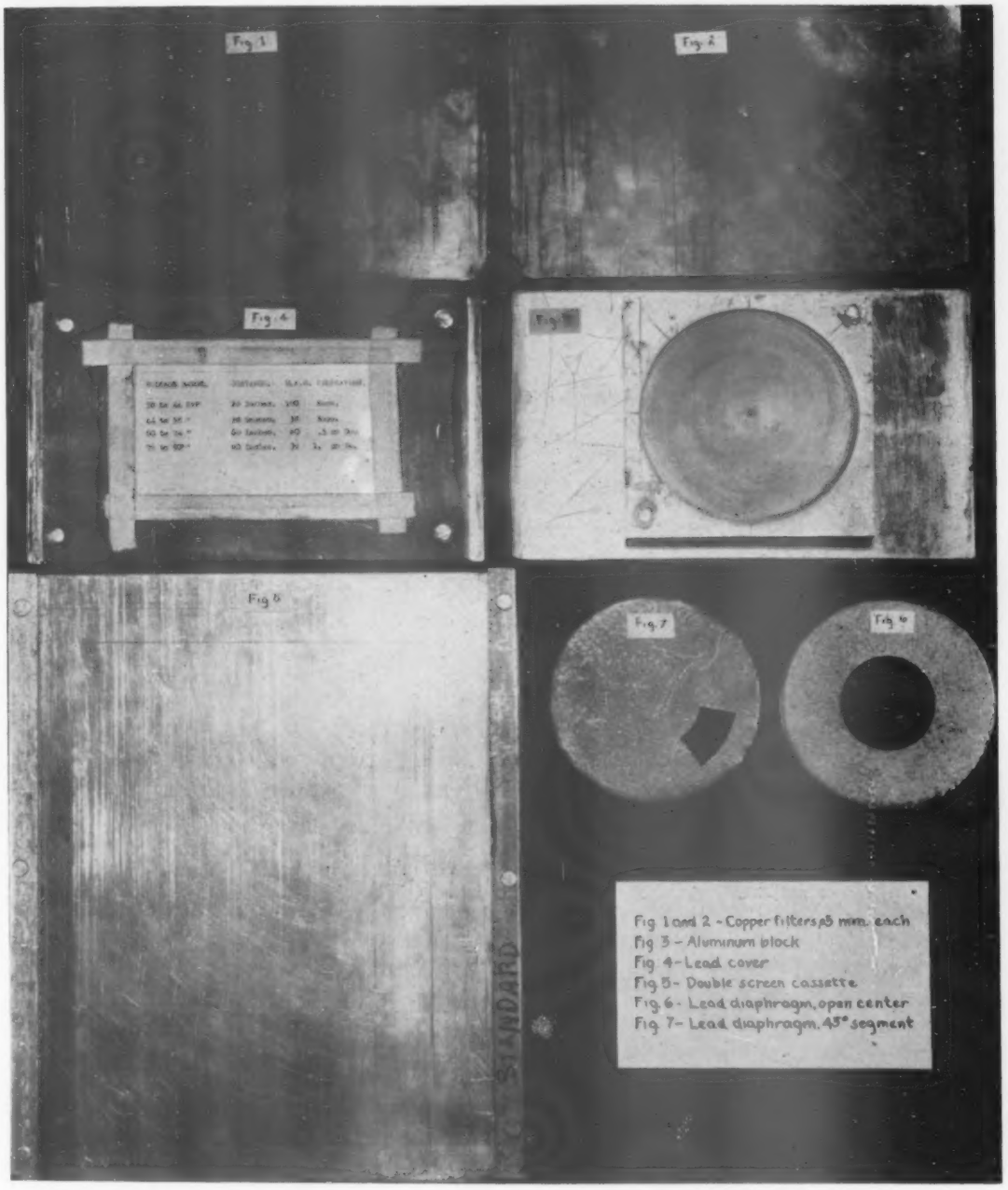
Fig 1
Fig 2
Fig 4
Fig 5
Fig 6
Fig 7
Fig 1 and 2 - Copper filters, 3 mm. each
Fig 3 - Aluminum block
Fig 4 - Lead cover
Fig 5 - Double screen cassette
Fig 6 - Lead diaphragm, open center
Fig 7 - Lead diaphragm, 45° segment

Fig. 2

kv. (peak). The block has eight comparison divisions of 45° each. This allows a range of 16 kv. (peak) per film. Interpolation between two of the voltage settings proves satisfactory. Settings can be obtained for use with the high milliamperage or "flash" technique. Comparative film can be made up, slightly varying the exposure to permit the exact milliamperage and time used for chest technique.

There are many objections to the use of films for comparison of densities, but it is believed that this technique eliminates most of them. Known and unknown exposures are made upon contiguous areas of the same film. This eliminates differences

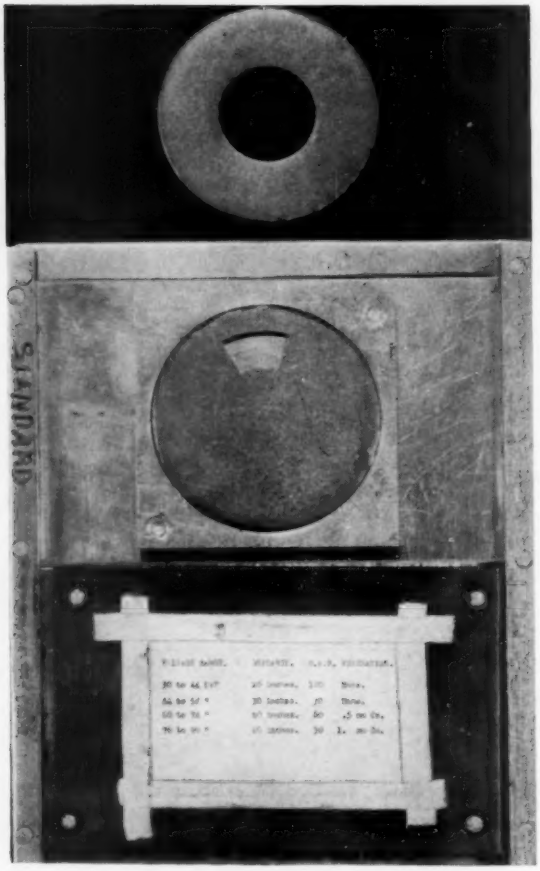

FIG. 3

in dark room technique and differences in film. Agitation of the film during development is desirable, but it is found in practice that failure to do this does not affect the results seriously. Reader error, which is the personal equation in the reading of the settings and the operation of the equipment, is less than with the sphere gap.

Another technique is suggested: This calibration block can be used to make eight densities on the known machine and eight on the unknown machine, on two halves of the same film. This method gives a greater range than the first method, but the densities are not as easily compared and the agitation of the film during development is much more important.

This calibration block can also be used for the following purposes:

1. Determining the kilovoltage difference of intensifying screens.
2. Matching screens in a cassette.
3. Checking saturation point of developing solutions.
4. Plotting the efficiency of one roentgen-ray tube against another.
5. Comparing speeds of various films in difference in kilovoltage.

CONCLUSIONS

A method is presented for the comparison of the roentgenographic performance of two roentgen-ray machines. The comparison is made in terms of the roentgenographic effect rather than the less useful kilovolts (peak). The equipment suggested is simpler than a sphere gap. This method can be used with shockproof equipment. The errors and accuracy are such as to make the method an improvement over the sphere gap method.

There are two obvious difficulties: the necessity of having a standard machine, and the necessity of carrying films from one machine to another. In most cases these difficulties are negligible.

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ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

ABDOMEN

Sherman, E. David. Gastro-intestinal manifestations of lymphogranulomatosis (Hodgkin's disease). *Arch. Int. Med.*, Jan., 1938, *61*, 60–82.

Two cases having localized lymphogranulomatosis involving the intestinal tract are added to the 73 which the author has found reported in the literature. In most of these, the diagnosis has been established only after histological studies, made possible by surgery or autopsy. Intestinal symptoms are frequent in cases of Hodgkin's disease, and secondary involvement of the tract is well recognized. In the early stages, nodular lesions are found only in the submucosa. Later, there may be extension of the lesions into the lumen whereby ulcerations are formed or there may be infiltrations into the other layers of the wall. In contrast to the sites of predilection for tuberculosis in the intestine, lesions of Hodgkin's disease are usually found in the upper portions of the tract, particularly in the stomach and duodenum. There may be ulceration through all coats with the development of perforation or hemorrhage. There may be dissemination to other organs such as the spleen, liver, or pancreas. Lymphadenoid tissue is especially involved. The first change is hyperplasia of the reticulum. Later, there is found a peculiar granulation tissue with a variety of cellular elements; small and large lymphocytes, reticulum cells, plasma cells, eosinophiles, neutrophiles, fibroblasts and mononuclear and multinuclear giant cells. Then necrosis occurs with the formation of hyaline fibrous tissue.

One of the two cases, reported by the author, showed typical Hodgkin's lymphogranulomatosis of the stomach; the other, similar lesions in the jejunum. In reviewing the literature, Steindl's case is cited, where a gastric resection was performed because of a localized lesion in the pylorus and prepyloric regions and regionally enlarged lymphatics. This patient was well

one year following operation. Several other cases were likewise treated surgically with success. Of all such more or less localized cases, 50 per cent occurred between the ages of forty and sixty. Twice as many males were afflicted as females. In the gastric cases, the chief symptoms were epigastric pain and distress of varying severity after meals: eructations of gas, weakness, loss of appetite (and weight), nausea and even vomiting; occasionally, hematemesis and melena. Such symptoms may have been noted for only a few weeks or for several years. Physical examination sometimes revealed palpable resistance or a mass in the abdomen. Irregular bouts of fever were occasionally present. Anemia and leukopenia were frequent. Either peptic ulcer or carcinoma was suspected.

With localization in the intestines, either inflammatory or obstructive symptoms were predominant. In the former, tuberculous enterocolitis was usually suspected; in the latter, carcinoma.

Roentgenologically, the evidence was consistent with either carcinoma (although the peristaltic waves progressed through the lymphogranulomatous lesions more conspicuously than in the case of carcinoma) or peptic ulcer. Ruggles and Stone have expressed the opinion that "when gastric peristalsis persists and there is a lesion of the stomach, this lesion is most likely to be a lymphoblastoma." With involvement of the intestine, the roentgen evidence is simply of an "enteritis" or obstruction.

Roentgen therapy has been strongly recommended, either as definite treatment or after surgery.—*A. A. de Lorimier.*

FOUCAR, F. H. Syphilis of the gastro-intestinal tract. *Am. J. Path.*, Jan., 1937, *13*, 65–80.

The author was able to find in the literature 12 cases of what appeared to be syphilis of the gastrointestinal tract. These are abstracted and in addition a synopsis of an additional such case is included. Textbooks have stressed certain characteristics of syphilis such as: the intimal reaction of larger arteries, thromboses of veins, plasma cell reaction in granulation tissue, the formation of giant cells and the survival of elastic fibrils. The author emphasizes the fact that such criteria may suggest syphilis but they do not constitute incontestable evidence. Serology may be negative and moreover even when positive, it must be realized that other conditions such as cancer may be coincidental to a syphilitic infection. In most of the cases previously reported there was not substantiation of the diagnosis by the finding of the treponemata. Several suggested to the author the possibility of "Durand-Nicholas-Favre's" disease.

The author's case was a white male, aged thirty-two, who was first studied in 1935. His mother died of apoplexy at the age of sixty; his father and two sisters died of carcinoma; two brothers were living and well. No history could be obtained as to a chancre though his wife was known to be a syphilitic and had received antisyphilitic treatment. During 1934 and until the time of his recent entry, the patient himself had been given sixteen doses of neosalvarsan; three doses of bismuth; two doses of mercury and five doses of potassium tartrate, because of repeated two- and three-plus positive Kahn reactions (though the Wassermann reactions were repeatedly negative or plus-minus). His complaints included dull pain in the right lower quadrant of the abdomen, poor appetite, watery stools. A mass could be palpated in the right lower quadrant (patient had had an appendectomy about a year previously). This mass was tender; it was movable and seemed to measure about 10.5 cm. in diameter, though its size was reduced after giving an enema. His normal weight was 134; his present was 116. Spasm was reported at the time of the first gastrointestinal study and after giving atropin, the roentgenologist reported a large annular carcinoma of the transverse colon, close to the hepatic flexure; approximately 8 cm. of the gut is implicated. A laparotomy was performed and a section of the proximal transverse colon was removed, together with regional enlarged lymphatics. Microscopical studies failed to show the characteristics of carcinoma and after several types of stainings, treponemata were demonstrated; they were located in the granulomatous tissue between the necrotic mucosa and the "core" of the gumma.—*A. A. de Lorimier.*

GUTMANN, RENÉ-A., and BERTRAND, IVAN. Le cancer gastrique érosif a marche lente. (Erosive slow-growing gastric cancer.) *Presse méd.*, May 21, 1938, *46*, 814–817.

This type of cancer is characterized clinically by irregular episodes of non-progressive pain for several years; roentgenologically by an atypical retraction of the lesser curvature and

functional rigidity in the prepyloric area; macroscopically by extensive superficial ulceration; microscopically by involvement of the mucosa not extending into the muscularis mucosae or muscularis. The glands are not involved. At operation the prepylorus is found thickened, and when opened, a superficial ulceration, sometimes saddle shaped, is found. —*M. L. Sussman.*

Taussig, Helen B. Complete transposition of the great vessels; clinical and pathologic features. *Am. Heart J.*, 1938, *16*, 728–733.

In 1930, 97 cases of this condition associated with a wide variety of other malformations had been reported in the literature. The condition has rarely been recognized during life and the diagnosis has been regarded as difficult. The author believes that there are characteristic roentgenoscopic findings which make the ante-mortem diagnosis possible, and reports 4 cases in which the ante-mortem diagnosis was confirmed post mortem.

In complete transposition of the great vessels, the aorta arises from the right ventricle and the pulmonary artery from the left ventricle. For the condition to be compatible with life there must be an additional malformation permitting communication between right and left sides of the heart, i.e., a patent ductus arteriosus, a patent foramen ovale, or an intraventricular septal defect, or some combination of these.

The diagnosis is based on the finding of a persistent cyanosis and the characteristic changes in the appearance of the great vessels. The time of appearance and the intensity of the cyanosis are variable and dependent on the type and extent of the associated malformation. In this condition the aorta at the base of the heart lies anterior to the pulmonary artery and farther to the left than normally and the pulmonary artery lies posteriorly and farther to the right. The shadow produced by the great vessels is narrower than normal in the antero-posterior view and there is an absence of the pulmonary conus. When the patient is rotated to the left anterior oblique projection the aorta and pulmonary vessels lie side by side and the width of the vascular trunk is greater than normal. There is also enlargement of the heart, the enlargement being particularly marked in the right ventricle on the right side. In place of the convexity usually produced by the pulmonary conus, there is a concavity in the upper left border of the cardiovascular shadow. These findings were present in the author's 4 cases in spite of a variety of other malformations associated with the transposition of the great vessels.—*W. A. Evans, Jr.*

SKELETAL SYSTEM

Brdiczka, G. Vererbbare und angeborene multiple Synostosen an zahlreichen Gelenken der oberen und unteren Extremität. (Inheritable and congenital multiple synostoses in multiple joints of the upper and lower extremities.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Sept., 1938, *58*, 228–233.

Fusion of bones in the wrist and ankle is not rare and has been frequently reported. Synostosis between the navicular and lunate bones or between the lunate and hamate is quite common. The case which the author reports is unusual because of the extensive synostosis throughout the extremities. Four somewhat similar cases were found in the literature, but none showed such marked changes. The patient was a girl, aged nineteen, whose deformities of the arms and legs had been present since birth and whose mother and maternal relatives had similar deformities. The fingers of both hands contained only two phalanges. In the wrist the multangulum majus, navicular and pisiform bones were isolated, but there was fusion of all the other carpal bones. In spite of these changes there was fairly good function. Supination was limited and there was also restricted motion at both elbow joints where deformities and partial ankylosis were observed involving the radius, ulna and humerus. The shoulder joints were normal. In the feet, the toes were unusually short and the metatarsal region was elongated. The fourth toe was without a distal phalanx and nail and all of the other toes had only two phalanges. There was fusion between the talus and calcaneus and between the cuboid and second and third cuneiform bones. The first cuneiform and navicular bones were also fused. No abnormality was demonstrated in the knee or hip joints or in the vertebral column. The condition was traceable to a maternal grandfather and appeared in twelve descendants, both male and female.—*W. A. Evans, Jr.*

Melamed, S., and Chester, William. Osseous form of Gaucher's disease. *Arch. Int. Med.*, May, 1938, *61*, 798–807.

The author refers to Ludwig Pick's excellent review of the osseous form of Gaucher's disease and reports one such case. The patient was a twenty-six year old Polish Jew who was first studied because of joint symptoms, at which time he was thought to have a polyarticular rheumatism, though there was no fever. The following year he was found to have a greatly enlarged spleen and on the basis of a splenic puncture the diagnosis of Gaucher's disease was made. Symptoms continued with oral and nasal hemorrhages and progressive anemia during the next six years, and the spleen became so large that a splenectomy was performed. Following splenectomy, the anemia improved but two years later he began to have pains in his back; during the following four years it was noted that his height had shortened from 60 inches to 40 inches and he developed a fracture of the sternum, with regional swelling of the soft tissues. Hemorrhages recurred but during his last eight months, bone achings were his chief complaints. His hemoglobin became reduced to 48 per cent; red blood cells, 2,900,000; nucleated reds, 17,000; white cells, 6,000; platelets, 90,000. The bilirubin content of the blood was 0.3 mg. per 100 cc.; icterus index, 4. Chemical analyses showed: sugar, 80; urea N., 11.3; calcium, 10.4; phosphorus, 2.9 mg.; cholesterol, 138 mg. and cholesterol esters, 101 mg. per 100 cc.; Wassermann negative.

Roentgenography revealed marked destruction of the fifth dorsal vertebra; collapse of the 7th and 11th dorsals and 1st lumbar (to one-third its normal size); marked absorption of the 9th dorsal and 1st lumbar; cystic changes in both innominate bones, especially in the regions of the acetabula; cystic changes and osteosclerosis in the femora, tibiae and humeri and marked deossification of the ribs. The skull appeared normal.—*A. A. de Lorimier.*

DUNLOP, JOHN. Transcondylar fractures of the humerus in childhood. *J. Bone & Joint Surg.*, Jan., 1939, *21*, 59–73.

In this paper, the author presents a type of fracture which involves the lower end of the humerus in young children, and which is most prevalent between the ages of five and twelve years. These fractures have been termed "diacondylar" by many authors, but Dunlop believes that the term "transcondylar" is more truly descriptive of the injury. This fracture passes across the broadened distal end of the humerus, and through the very thin portion of the bone known as the olecranon and coronoid fossae. Some authors have spoken of it as an epiphyseal separation, but there is no epiphyseal line at this level of the bone. The epiphyseal line between the capitellum and the trochlea and the diaphysis of the humerus is distal to the line of fracture.

Dunlop decided to use skin traction in the straight lateral position with the child in bed, instead of the more usual method known as the Robert Jones position. Imperfect position of the fragments when the latter method is used may be due to: first, rotation of the upper and lower fragments in their relation to each other; second, the distal fragment slips posteriorly due to the pull of the strong triceps muscle. With Dunlop's traction method, reduction can be obtained in about twenty-four hours but the method requires the very closest attention of the surgeon.

Dunlop's procedure is as follows:

1. A correct interpretation of the type of fracture from the roentgenograms.

2. Admission of the patient to a hospital where the procedure can be fully followed. In addition to the simple apparatus, access must be had to a portable roentgen-ray unit.

3. Administration of morphine hypodermically to obtain relaxation and to allow the necessary movement of the arm.

4. Application of traction to the arm up to the elbow joint.

5. Gradual straightening of the arm and attachment of the weights to the traction apparatus.

6. Elevation of the side of the bed toward the traction.

7. Attachment of a binder or sheet about the body of the patient to hold him in bed, as there is a tendency for the patient to slide toward the weights.

8. Taking of anteroposterior and lateral roentgenograms within approximately half an hour. Much can be learned from these films as to:

   a. Amount of weight necessary.

   b. Elevation of pulley on standard.

   c. Necessity for use of counterweight with sling over upper arm.

9. Taking of additional roentgenograms in about three or four hours which will indicate whether there should be an increase in the weight used, or a change in the angle of traction.

10. Judicious rearrangement of the traction to obtain good alignment, with the patient completely relaxed by morphine sedation.

11. Removal of traction and application of splint and sling. When roentgenograms show sufficient callus, and the fragments appear to be firmly united, the traction is removed while the surgeon holds the arm. Then very gradually the elbow is flexed until approximately a right angle is obtained. While the arm is still being held, a posterior plaster-of-Paris splint is applied and the arm is put into a sling. The child may then be allowed out of bed, and as soon as he can walk steadily he may return to his home.

12. Removal of splint and taking of further roentgenograms. In three or four weeks, the splint is removed and the elbow is examined roentgenographically to see if sufficient union has taken place to allow removal of the plaster splint. The arm is then tied to the neck with a collar and cuff.

13. Institution of movement, at first by lowering and raising the forearm by the collar and cuff, and later by allowing freedom of movement. It is not only unnecessary but also unwise to stimulate or to enforce straightening of the elbow. It is advisable to encourage the use of the arm by normal movements.

An elbow with full function without deformity should be the result in approximately three or four months.—*R. S. Bromer.*

Camp, John D., and Good, C. Allen, Jr. The roentgenologic diagnosis of tumors involving the sacrum. *Radiology*, Oct., 1938, *31*, 398–403.

Forty-one cases of roentgenologically diagnosed tumors of the sacrum are reported. These cases fell in three groups arising (1) from the sacral canal, (2) from the body of the sacrum, and (3) from structure adjacent to the sacrum.

Ependymal cell gliomas are the most common tumors arising within the sacral canal and they cause erosion of the canal by expansion and direct pressure. They do not invade the sacrum.

Chordoma, a remnant of the notocord, is the most common tumor arising from the sacrum. This tumor usually causes an expansion of the sacrum especially in the anteroposterior view. However, it is usually impossible to make a pathological diagnosis from the roentgenogram, although the invasive character of the lesion warrants the diagnosis of a malignancy.

Seven of the 41 cases arose from structures adjacent to the sacrum.—*J. H. Harris.*

Levinthal, Daniel H., and Wolin, Irving. Unilateral congenital elevation of the ilium or congenital dislocation of the sacro-iliac joint. *J. Bone & Joint Surg.*, Jan., 1939, *21*, 193–196.

The authors report an unusual developmental anomaly of the pelvis, which resembled in several respects the obliquely contracted pelvis of Nägele. Roentgenograms of their case showed a marked pelvic asymmetry, with a right lumbar scoliosis. There was a spina bifida of the first sacral segment, and the remaining neural arches of the sacrum appeared to be wide open. The right ala of the sacrum was partially absent, and was smaller than the left. The sacral foramina were approximately equal in size. Only one small coccygeal segment was visualized, articulating with the right lower border of the sacrum. The right ilium was distinctly smaller than the left, and its crest was half an inch lower. The pubic symphysis was displaced to the left. The right ischial and pubic rami were displaced superiorly, as was the ischial spine, which was apparently much enlarged. The curve of the right iliopectineal line was flattened, and the pelvic inlet assumed an obliquely elliptical configuration. The right posterior inferior spine was absent, the greater sciatic notch extending to the posterior superior spine. The auricular surface of the right ilium was very small and made a distinct articulation with the right transverse process of the fifth lumbar vertebra; the appearance was that of a congenital elevation of the ilium or sacroiliac dislocation. The acetabula were on about the same horizontal level, but the right one was more oblique. The right femoral head was transversely elliptical.

This condition was apparently the result of arrest and distortion of a normal epiphyseal development in the sacral and iliac centers. It represents an arrest of the development of the centers for the right first and second transverse processes. The distortion of the right hip with the obliquity of the acetabulum resembled the structural changes associated with congenital dislocation of the hip.

Instead of the term "sacroiliac dislocation," the authors consider "congenital elevation of the ilium" a better descriptive term for the anomaly presented.—*R. S. Bromer.*

GHORMLEY, RALPH K., and VALLS, JORGE E. Metastasis to bone from carcinoma of the gastro-intestinal tract. *J. Bone & Joint Surg.*, Jan., 1939, *21*, 74–78.

The authors surveyed the records of cases in which a diagnosis of carcinoma of the gastro-intestinal tract was made at the Mayo Clinic in the fifteen years from 1922 to 1936 inclusive. The growths occurred in the esophagus, the stomach, the duodenum, the jejunum, the colon, the sigmoid, the rectosigmoid, and the rectum. Cases in which tumors were primary in the liver, the pancreas, or other parenchymatous organs of the abdomen were not included in the series. They tabulate the situation of 51 metastatic growths arising from 43 carcinomata of the gastrointestinal tract and the incidence of metastasis to bone from such carcinomata.

They found osteoclastic lesions in 32 cases, osteoplastic lesions in 5 and mixed lesions, both osteoclastic and osteoplastic, in 2. In 2 others the type of lesions was not noted in the records and in 1, the characteristics were indeterminate The following points are emphasized by the authors:

1. Carcinomatous lesions of the gastro-intestinal tract may metastasize to the skelton.

2. Such metastatic growths will be discovered less frequently in clinical than in post-mortem examinations.

3. The bones of the trunk are more frequently the sites of such metastatic lesions than are the other bones.

4. On the basis of their study, they place the incidence of metastasis to bone from 0.2 to 0.5 per cent of all cases of carcinoma of the gastrointestinal tract, with the highest incidence of such metastasis in cases of carcinoma of the rectum.—*R. S. Bromer.*

BRAILSFORD, JAMES F. Osteochondritis of the adult tarsal navicular. *J. Bone & Joint Surg.*, Jan., 1939, *21*, 111–120.

Brailsford describes a characteristic lesion in 9 cases of osteochondritis of the tarsal navicular in adult women. This consists of an oblique splitting of the navicular with separation into two fragments; the inner fragment gradually slides over the head of the astragalus to its medial side while the outer fragment overrides the dorsal surface of the second and third cuneiforms. This breach between the two fragments reduces the distance between the proximal articular surfaces of the second and third cuneiforms, on the one hand, and the head of the astragalus, on the other, and ultimately these cuneiform surfaces may even articulate with the head of the astragalus. In the later stages, severe osteoarthritic changes develop in the midtarsal joint. A lesion of this severity may be found on both sides. More frequently, however, while one side presents the appearances described, the other shows less extensive changes such as osteochondritis dissecans, or mere compression of the plastic outer third of the navicular. All of the 9 patients showed evidence of pathological changes in the navicular of each foot. No cases presenting similar roentgenographic appearances were observed in men.

The ages of the patients ranged from twenty-two to fifty-nine. In the 2 youngest patients, no secondary arthritic changes could be detected in the affected bones. In all the others, with one exception, marked osteoarthritic changes were evident.

Osteochondritis of the navicular in the adult does not present that sequence of changes seen in Köhler's disease. It runs a more chronic course and leads to a progressive deformity, a listhesis of the navicular which appears to be rarely investigated roentgenographically until secondary osteoarthritic changes are beginning to develop in the unstable midtarsal joint. It is then a crippling, painful deformity.—*R. S. Bromer.*

CORPER, FRANKLIN J. Osteochondritis ischiopubica in childhood. *Am. J. Dis. Child.*, Nov., 1938, *56*, 957–964.

Corper reports 4 cases of a condition which roentgenologically resembles that previously described under the term osteochondritis or osteochondrosis ischiopubica and also conforms to the descriptions of osteochondrosis juvenilis as seen in other parts of the bony structures. Clinically, the degree of pain manifested and the intensity of the focal symptoms were unlike those seen in other osteochondral lesions, i.e., Perthes' disease or Osgood-Schlatter's disease. In his cases there was little or no pain after the acute symptoms had subsided, although destructive changes could be demonstrated in the roentgenograms for several weeks after the apparent onset. He thinks that the lesions of the synchondrosis may have been present for some time before they gave rise to any subjec-

tive symptoms, and that the acute pain and tenderness occured only after an already disturbed or diseased tissue had been further irritated, either by trauma or infection. So it might be rational to name the forms in which there are minor symptoms and classic roentgenologic lesions osteochondrosis and those in which there are acute symptoms osteochondritis.

He quotes Zeitlin who made the following distinction in naming the roentgenologic picture. In osteochondrosis the process of decalcification and dystrophy is strictly localized in the synchondrosis, with normal appearing or slightly condensed bone on the side of the ischium and of the pubis at their junction with the decalcified area. The affected focus remains in this condition for several weeks or months; then the process of restitution begins. The condition in which the decalcification and dystrophy are not limited to the ischiopubic junction he calls osteochondritis ischiopubica. There is extension of the process to the adjoining bone, forming one continuous focus. Such involvement is likely to continue for months or years, with, however, relatively mild clinical symptoms. In cases of ischiopubic disease, the characteristic projection of a bony cartilaginous mass into the obturator foramen reaches such size as to be incompatible with the small mass sometimes seen in normal ossification.

The differential diagnosis concerns chiefly simple trauma, the acute and subacute types of osteomyelitis, tuberculosis and syphilis. The most important factors in determining the diagnosis are the onset with rapidly progressive local manifestations, the relatively mild accompanying symptoms and the characteristic roentgen picture. The prognosis is favorable, requiring only rest of the parts affected, and no cases have been reported of permanent disability following this form of osteochondritis.—*R. S. Bromer.*

Summerfeldt, Pearl, and Brown, Alan. Osteodystrophia fibrosa. *Am. J. Dis. Child.*, Jan., 1939, *57*, 90–101.

The authors report 2 cases, one a girl, aged six, the other, aged ten, who exhibited precocious puberty, yellow pigmentation of the skin, and osteodystrophy, the last progressing to cystic formation which resulted in fractures and skeletal deformity. Increase in the basal metabolic rate, increase in the blood pressure, disturbance in the lipoid metabolism and decrease in carbohydrate tolerance were found. The presentation of these 2 cases contributes nothing new to the etiology of the condition but the authors consider them of interest due to the abnormal values for cholesterol, blood fat and blood sugar which were found. McCune and Bruch, in a recent article, gave a detailed description of this entity which they termed osteodystrophia fibrosa. Apparently in the 2 cases reported some disturbance of lipoid metabolism was occurring, either primary or secondary. Biopsy of bone should have confirmed the chemical findings but the microscopic examination of bone tended to make the clinical picture more confusing. In the latter, nothing in the nature of cystic formation could be seen and no foam cells were found. Studies in the 2 cases, showed a negative balance for calcium, but the percentage of calcium excreted in the urine was within normal limits, which made the diagnosis of hyperparathyroidism improbable.—*R. S. Bromer.*

Clifton, Willie Mae, Frank, Albert, and Freeman, Smith. Osteopetrosis (marble bones). *Am. J. Dis. Child.*, Nov., 1938, *56*, 1020–1036.

Although reports of 80 cases of diffuse osteopetrosis in the living subject have appeared in the literature, in only a few cases has the condition been studied completely or followed for a long period. The authors report a case of osteopetrosis in a child of five years which began *in utero* and was followed from early infancy. They present the clinical progress of the disease as shown by roentgenograms and also metabolic, chemical and histologic studies.

The cause of osteopetrosis or marble bones is unknown. Almost all the features characteristic of marble bones were demonstrated in the authors' case. These include stocky build, square forehead, pigeon breast, bowed legs, atrophy of the optic nerves since early infancy, arrested dentition, constant purulent rhinitis with frequent infections of the respiratory tract and generalized increased density of the bones. The diagnosis was made by roentgen study. The characteristic changes in the roentgenograms were: The bones of the entire body showed increased density with loss of normal structure. The shadow of the marrow cavity was reduced, sometimes even obliterated. The greatest density was shown in the vertebral

bodies, in the central part of the pelvis, in the base of the skull and in the ends of the long bones. There was broad and symmetrical clubbing of the ends of the long bones. The proximal end of the humerus and the distal end of the femur showed this especially well. There was a narrowing of the sella turcica and clublike thickening of the posterior clinoid processes. Narrowing of the optic foramina produced atrophy of the nerves and blindness. Similarly, there may be involvement of the auditory nerves or stenosis of the paranasal sinuses. The delay or arrest of dentition is thought to be due, probably, to sclerosis of the alveolar bone but may be due also to some involvement of the tooth buds themselves.

In osteopetrosis, the ossification centers appear at the normal time and although involved in the sclerosing process, proceed to fusion with the shaft at the usual time. Longitudinal growth, however, is sometimes retarded as in the case reported in this paper.

In this patient, as in other reported cases, a positive balance of calcium was maintained with diets high and low in calcium during the administration of ammonium chloride, thyroid and parathyroid extract. A positive calcium balance has also been reported, maintained with a diet containing vitamin D. No change was noted due to administration of thyrotropic pituitary substance. In the authors' patient, determinations of the phosphatase content of serum and bone, both rib and tibia, were low. The chemical composition of the bone ash was within normal limits, except a percentage of high ash was found in the more distinctly pathologic bone. Hypochromic anemia began to develop in the patient during the fourth year which did not respond to iron therapy. As a general rule, however, the anemia does not parallel the progress of the sclerosis.

The prognosis depends largely on the rapidity with which the sclerosis advances. In some cases in which the condition developed *in utero* there have been stillbirths. When osteopetrosis causes enough symptoms to be diagnosed during early infancy the expectancy of life is extremely short. Under the most favorable circumstances the patients are handicapped for adult life. The brittleness of the bones results in pathologic fractures, causing frequent periods of incapacity. Blindness or impaired vision, sometimes associated with subnormal mentality, increases the dependent status of the person with marble bones who does reach adult life. There is no specific treatment for osteopetrosis. The process seems to be a true developmental disease characterized by faulty differentiation of oseous and hematogenic tissue.—*R. S. Bromer.*

JETTER, WALTER W. Paratyphoid fever complicated by multiple foci of osteomyelitis. *Am. J. Dis. Child.*, Oct., 1938, *56*, 846–851.

Jetter states that osteomyelitis complicating typhoid fever is not particularly uncommon. Osteomyelitis of paratyphoid origin is more rare, even when the comparative infrequency of paratyphoid fever is taken into consideration. The rarity of osseous complications is explainable in cases in which the paratyphoid infection produces the so-called food poisoning syndrome, which is characterized by acute onset, fever, prostration, rapid pulse, nausea and vomiting, with subsidence in a few days. When the picture suggests typhoid fever, however, as is frequently the case, especially with the paratyphoid B strain, the complication of osteomyelitis would be expected as often as with true typhoid fever. According to Veal and McFetridge, the condition occurs in the late stages of paratyphoid fever or during convalescence. The onset is acute or subacute, but the acute clinical manifestations so often found with pyogenic infection are not present.

Jetter reports a case of paratyphoid fever due to *S. schottmülleri* which ended fatally. Postmortem observations were secured. Roentgen examination showed osteomyelitic foci in the shaft of each tibia and fibula, in each humerus, the right pubis and ischium, in the right ulna and radius, and suggestive areas in each femur. As far as he can determine, it is the nineteenth recorded case of osteomyelitis complicating paratyphoid fever and the second in which the foci were multiple.—*R. S. Bromer.*

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